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VOL. IX JULY, 1955 NO. 3

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

IN THIS ISSUE: Inger — *Revision of* Plesiops • Forster — *New Family of Spiders* • Emery — *Submarine Topography South of Hawaii* • Erskine — *Reproduction and Affinities of* Dasyptilon • Strasburg — *Differentiation of Blenniid Fishes* • Palmer — *Geomorphic Contrasts Within the Koolau Range* • Haig — *Fishes Killed by Mauna Loa. III* • Dell — *Land Mollusca of Nissan* • Hand — *Structure, Affinities, and Distribution of* Tetraplatia volitans • Shiino — Paranesippus incisus, *New Parasitic Copepod* • Chapman — *Algae from Funafuti* • Dell — *Tornatellinid Mollusk from the Solomons* • Randall — *Genera of Surgeon Fishes* • NOTES

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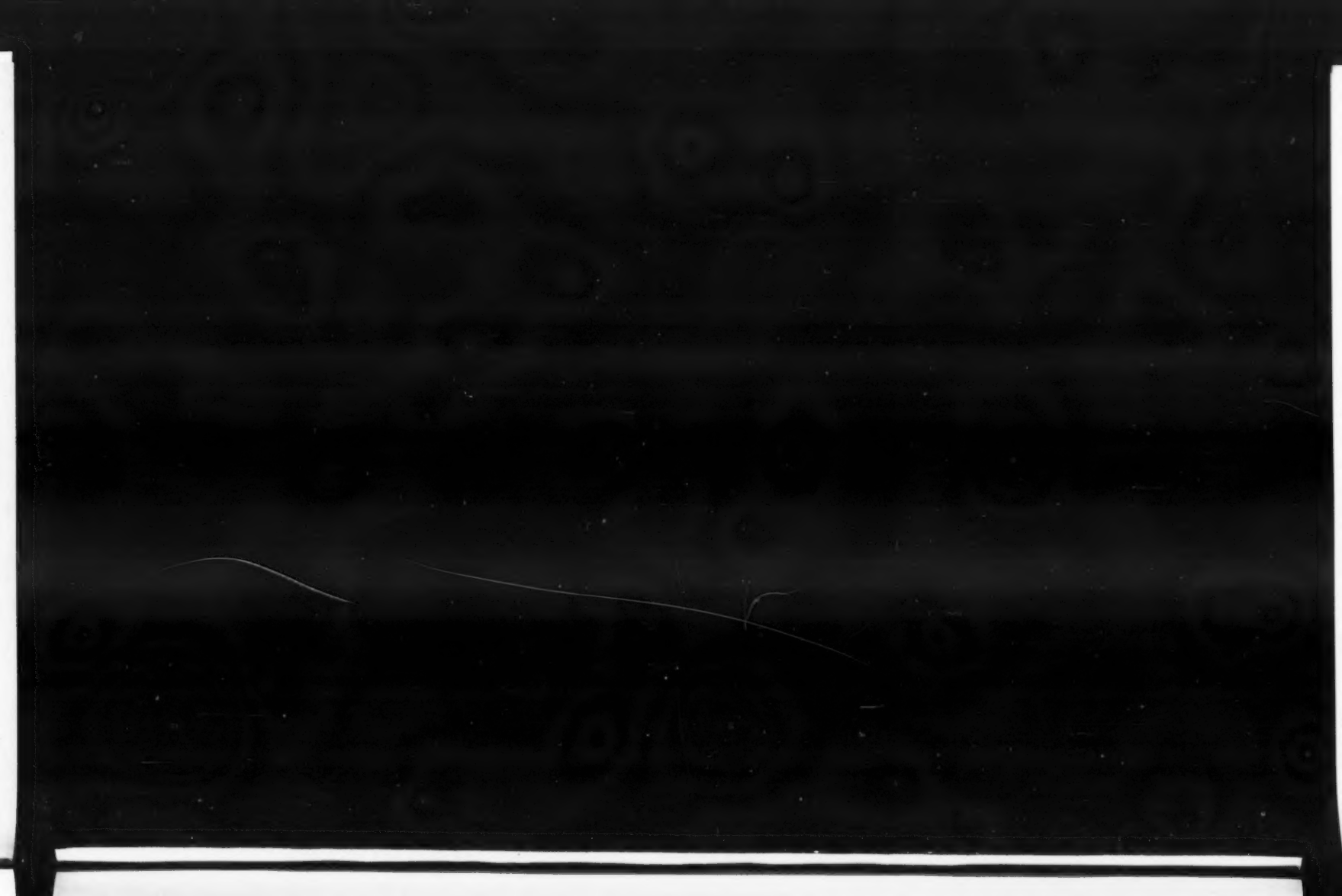

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Previous issue published April 14, 1955

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PACIFIC SCIENCE is published quarterly by the University of Hawaii Press, in January, April, July, and October. Subscription price is $3.00 a year; single copies are $1.00. Check or money order payable to University of Hawaii should be sent to University of Hawaii Press, Honolulu 14, Hawaii, U.S.A.

A Revision of the Fishes of the Genus *Plesiops* Cuvier

ROBERT F. INGER[1]

IN THE COURSE of a routine examination of the plesiopids in the collections of the Chicago Natural History Museum, a specimen of *Plesiops oxycephalus* Bleeker, previously recorded only by Bleeker, and four specimens of an undescribed species mislabeled *P. nigricans* and *P. melas* were found. These discoveries and the observation made by Smith (1952) that Indo-Pacific references to *nigricans* were incorrect prompted a study of the entire genus.

Throughout this study Mr. L. P. Woods, Chicago Natural History Museum, was consulted on many points; his helpful advice and reading of the manuscript are greatly appreciated. I am grateful to Dr. L. P. Schultz, United States National Museum, for his critical reading of the manuscript and for the loan of an extensive collection of *Plesiops*. Thanks are also due to Mr. N. B. Marshall, British Museum (Natural History), for the loan of Red Sea material; to Dr. P. Kähsbauer, Naturhistorisches Museum, Vienna, for notes on the type of *Plesiops altivelis* Steindachner; to Dr. A. Zilch, Senckenbergische Naturforschende Gesellschaft, for data and photographs of Rüppell's specimens of *nigricans* and *coeruleolineatus*; and to Dr. K. H. Barnard, South African Museum, for data on Natal specimens at his disposal. The figures are the work of Miss Margaret Bradbury, Chicago Natural History Museum.

Methods of Counting and Measuring

All fin rays with separate bases were counted. Lateral line scale counts include only tubulated scales. In the upper lateral line the count begins at the upper corner of the gill opening. The lower lateral line ends at the caudal flexure. The mid-lateral scale count starts at the gill opening just above the pectoral base and ends at the caudal flexure. A transverse series of scales was counted from the origin of the dorsal fin caudad and ventrad to the lateral line. A second transverse series was counted from the origin of the anal fin forwards and upwards to the lateral line. Neither transverse series includes the lateral line scale or fin sheath scales. Gill raker counts include all rudiments and developed rakers on the first arch. The raker at the angle is considered as part of the upper limb.

Measurements up to 120 mm. were made with vernier calipers graduated to 0.1 mm. In the few instances of larger fishes, a steel rule calibrated in half millimeters was used. All measurements are given to the nearest half millimeter. Standard length is taken as the distance from the tip of the head to the caudal flexure, head length as the distance between the forward tip and the end of the gill membrane, and body depth as the maximum depth. Head length and body depth are presented as the ratio of standard length to these dimensions and are cited as "head" and "depth." Unless specifically stated otherwise, "length" signifies standard length.

Counts of all species are summarized in Table 3.

Except where noted the descriptions are based upon many individuals.

The abbreviations CNHM and USNM refer to the Chicago Natural History Museum and the United States National Museum.

[1] Chicago Natural History Museum. Manuscript received December 1, 1954.

PLESIOPS Cuvier

Dorsal X-XIII, 6–8, usually XI, 7 or XII, 7; anal III, 8; dorsal and anal spines pungent; dorsal membrane extending beyond tips of spines, incised at least before anterior spines; anal membrane usually incised before last two spines; pelvic I, 4; the first soft ray thickened and elongated, reaching at least to anal origin; all soft pelvic rays branched.

Vomerine and palatal teeth present, in bands; no lingual teeth; lower pharyngeal teeth acute; opercle without spines; pseudobranchiae present.

Head naked before orbit; post-orbital part of head with cycloid scales; body scales mostly ctenoid, with a sharply outlined center (Fig. 1) in adults; two lateral lines, the upper curving with the body profile and ending opposite or just behind last dorsal ray.

The peculiar scales with their distinctly outlined center, first noted by Rüppell (1828), distinguish *Plesiops* from the related genera *Paraplesiops* Bleeker and *Barrosia* Smith. *Paraplesiops* also differs from *Plesiops* in its possession of lingual teeth and obtuse lower pharyngeal teeth. The first soft pelvic ray in *Barrosia* is only feebly thickened. The dorsal membrane, scarcely notched, also distinguishes *Barrosia* from *Plesiops*.

Smith (1952) places *Plesiops altivelis* Steindachner, known only from the type specimen, in his newly defined genus *Barrosia*. Notes on the type of *altivelis* made by Dr. Kähsbauer confirm Smith's conclusion. The first pelvic ray of *altivelis* is not thickened and the lower pectoral rays have only one branch each. The former character separates *altivelis* from all species of *Plesiops* and the latter from the larger species, with which *altivelis* corresponds in size (standard length 100 mm.).

Plesiops gigas Steindachner (type locality Australia) belongs in the genus *Paraplesiops* as is indicated by its high soft anal and dorsal counts (11–12), the large number of scales (mid-lateral series 43), and the presence of lingual teeth.

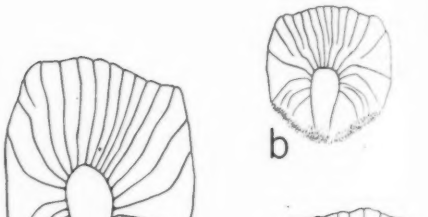

FIG. 1. Body scales of three species of *Plesiops*. *a*, *P. corallicola*; *b*, *P. cephalotaenia*; *c*, *P. oxycephalus*.

Assessor macneilli Whitley (type locality Queensland), described as being "superficially like a *Plesiops*," is of uncertain position because of the inadequate description given by Whitley (1935). The figure published subsequently by Whitley (1940) does indeed resemble *Plesiops* in habitus. The shape of the pelvics, the number of soft pelvic rays, the interruption of the lateral line, and the absence of lingual teeth also suggest relationship to *Plesiops*. However, the original description notes the presence of scales on the maxillary, the absence of palatal teeth, and the scarcely notched dorsal membrane, all of which characters would separate Whitley's species from *Plesiops*. Thickening of the first soft pelvic ray, diagnostic of *Plesiops*, is not mentioned by Whitley.

Notes on Ontogenetic Variation

Certain characters, such as the degree of branching in the lower pectoral rays and the development of an outlined circular or oval center on the scales, apparently change with age. Considering the latter character first, in *cephalotaenia* (Fig. 1*b*) an outlined center occurs only on the scales in the upper half of the middle third of the body in a fish 27.0 mm. long; in one 28.5 mm. long, scales with

this sculpturing are present in the entire upper half of the body; in an adult (48.5 mm.) all of the body scales have a delineated central area. The larger species *corallicola* (Fig. 1*a*) shows the same phenomenon, but with corresponding stages at greater lengths. For example, a 29.0 mm. fish has no scales with an outlined center; but such marked scales occur on the body between the axilla and the level of the soft dorsal in one 40.5 mm. long and over the entire body in one 58.0 mm. long. A young *nigricans* (34.0 mm.) has the characteristic plesiopine scales in the center of the body from the axilla to the end of the pectoral.

The division of the lower pectoral rays (Fig. 2) increases with size in two of the larger species. The type of *nigricans* (132 mm. total length) has four branches in each of the two lowest rays, five in the next ray, six in the next, and eight in each of the two next above. In Rüppell's second sepcimen (117 mm. total length, approx. 90 mm. standard length) the numbers of branches on the six lowest rays are 4, 6, 6, 8, 6, and 9 respectively, counting up from the ventral margin of the fin. (Data on both of these specimens are from Dr. Zilch.) The numbers of branches in a smaller individual (USNM 147530; 34.0 mm.) are 2, 4, 4, 4, 4, and 4. The same kind of variation, illustrated in Table 1, occurs in *corallicola* (Fig. 2*b*, *c*).

Plesiops multisquamata, the third large species, also has multibranched lower pectoral rays; but no information on ontogenetic changes is available.

The remaining species, which are smaller (maximum observed standard lengths in *oxycephalus* 65.5 mm.; gravid female of *cephalotaenia* 35.0 mm.; gravid female of *coeruleolineatus* 38.0 mm.), have only one or two branches in the lowest three pectoral rays and an observed maximum of four branches in the sixth ray, counting from the ventral edge (Fig. 2*a*). The frequency of individuals having two, three, or four branches in the sixth ray is shown in (Table 2).

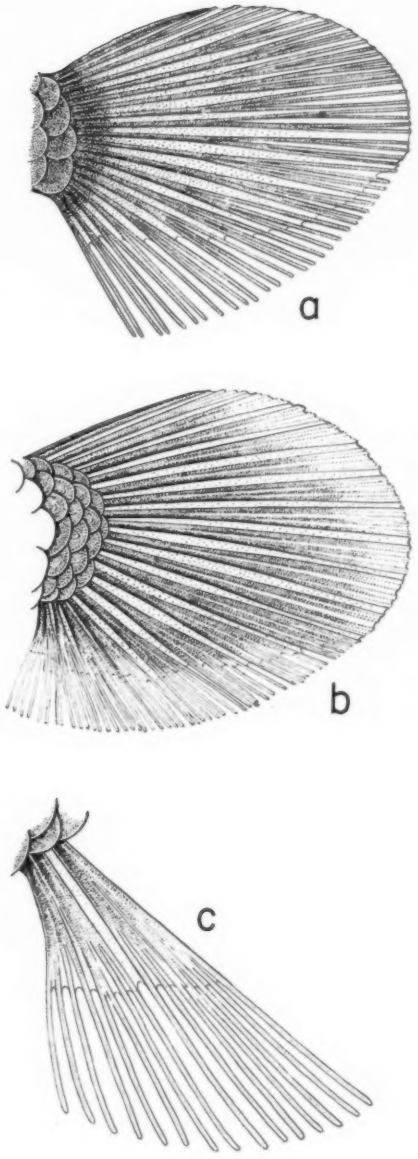

FIG. 2. Branching of rays in pectoral fins of: *a*, *P. coeruleolineatus* (× 5.3); *b*, *P. corallicola* (× 2.6); *c*, detail of lowest pectoral rays of *corallicola* (greatly enlarged).

TABLE 1

THE NUMBER OF INDIVIDUALS OF *Plesiops corallicola* WITH DIFFERENT NUMBERS OF BRANCHES IN THE FIRST, FOURTH, AND SIXTH PECTORAL RAYS (THE RAYS ARE COUNTED FROM THE VENTRAL MARGIN OF THE FIN)

STANDARD LENGTH OF SPECIMENS	NUMBER OF BRANCHES																	
	First ray				Fourth ray							Sixth ray						
	2	3	4	over 4	2	3	4	5	6	7	over 7	2	3	4	5	6	7	over 7
Under 40 mm.	4	3	1		2		2					2		2				
40–49 mm.	2	5	2				4	2						4	1			
50–69 mm.		1	11	2			1	3	1	1				1		3	2	
70 mm. and up			9	18					5	2	6					4	6	3

The sub-totals exhibit a tendency toward an increase in the number of branches with increase in size. This conclusion is borne out by applying a chi-square test to the sub-totals. The results of the test (chi-square = 11.84; n = 4; P = 0.02) show clearly that the distribution within the table is not at random. If, as seems evident from the data presented, the extent to which the lower pectoral rays are divided is dependent on size within species, the difference between the three small species on the one hand and the three large ones on the other in this character is probably a function of the differences in size at maturity.

KEY TO SPECIES OF *Plesiops*

The following key, which has been made simple in order to facilitate its use, should permit identification of about ninety per cent of all specimens. The exceptional individuals can be identified by comparison with the diagnoses appearing just before the description of each species.

1A. Dorsal spines usually XII; total gill rakers usually more than 13 . . . . . **2**

B. Dorsal spines usually XI; total gill rakers usually 13 or fewer . . . . . **coeruleolineatus** Rüppell

2A. A dark ocellus on opercle; ocellus separated from post-orbital black bars . . . . . **corallicola** Bleeker

B. A black stripe continuous from eye to end of opercle, or opercle without any black mark 3

3A. Four lowest pectoral rays with one or two branches each 4

B. Four lowest pectoral rays with more than two branches each, usually with four or more branches 5

4A. Caudal with a broad, crescentic orange (pale yellowish in preserved fishes) band, bordered peripherally by a narrower black band; no post-orbital black bar crossing preopercle . . . . . **oxycephalus** Bleeker

B. Caudal uniformly black or with a light margin; middle post-orbital bar crossing preopercle . . **cephalotaenia** new species

5A. Upper lateral line with 25–30 scales; mid-lateral scales 28–34 . . . . . **multisquamata** new species

B. Upper lateral line with 19–23 scales; mid-lateral series 23–27 . . . . . **nigricans** Rüppell

Plesiops nigricans Rüppell

Fig. 3*d*

Pharopteryx nigricans Rüppell, 1828, Atlas Reise nördl. Afrika, Fische, p. 15, pl. 4, fig. 2—Mohila, Red Sea.

Plesiops nigricans Rüppell, 1835, Neue Wirbelt., Fische, p. 5; Günther, 1861, Cat. Fishes Brit. Mus., 3: 363; Klunzinger, 1871, Zool.-Bot. Gesell. Wien, Abhandl. 21: 517.

Compilations of the last 75 years (e.g., Bleeker, 1875; Boulenger, 1895; Jordan and Seale, 1906; Weber and de Beaufort, 1929) have described *P. nigricans* Rüppell as a fish having a dark, light-rimmed opercular spot. However, Rüppell's figure (1828) of the type of *nigricans* does not show an opercular ocellus, nor is one mentioned in his description. Dr. Zilch has re-examined the type and another specimen collected by Rüppell and states (personal communication) that neither has such a mark.

Significantly, none of the above authors, with the exception of Rüppell, had specimens from the Red Sea or Africa. Smith (1952) suggests correctly that true *nigricans* Rüppell has never been found in the eastern Indian Ocean or in the Pacific. As far as I have been able to learn, only one specimen (USNM 147530) of *nigricans* has been recovered since Rüppell's time.

Gilchrist and Thompson (1911), Barnard (1927), and Smith (1949, 1952) have assigned certain fishes from southeastern Africa to this species. Their specimens, however, differ markedly from *nigricans*, and are described in this paper as *multisquamata*.

TABLE 2

NUMBER OF INDIVIDUALS OF THREE SPECIES OF *Plesiops* WITH DIFFERENT NUMBERS OF BRANCHES IN THE SIXTH RAY FROM THE VENTRAL EDGE OF THE PECTORAL FIN

STANDARD LENGTH	SPECIES	NUMBER OF BRANCHES		
		2	3	4
Under 40 mm. . .	*cephalotaenia*	4		
	coeruleolineatus	4		
	oxycephalus		1	
Subtotal.		8	1	
40–49 mm.	*cephalotaenia*	1	2	2
	coeruleolineatus	9	2	
	oxycephalus	3		1
Subtotal.		13	4	3
50 mm. and up .	*cephalotaenia*			2
	coeruleolineatus	1	1	
	oxycephalus			2
Subtotal.		1	1	4

Diagnosis: Dorsal spines XII; lateral line 19–23 + 14–17; scales in mid-lateral series 23–27; scales in transverse series 3–4/1/8–9; total gill rakers on first arch 18–19; two lowest pectoral rays with at least four branches each in fishes over 45 mm.; lower pectoral rays free in distal halves; standard length up to 100 mm.; opercle without large ocellus; head and body often with minute blue or whitish spots; caudal fin black.

Description: Dorsal XII, 7; pectoral 20–22; pelvic I, 4; anal III, 8; gill rakers 6 + 12; total length to 132 mm.; standard length to 105 mm.

Body oval or oblong, compressed; dorsal profile convex, rising in feebly curved line to dorsal origin; line from snout to dorsal origin making a 30 degree angle with mid-lateral line; ventral profile convex, sloping in straight line from snout to insertion of pelvic; snout pointed in profile, shorter than eye; mouth oblique; maxilla reaching perpendicular from hind border of orbit; anterior nostril midway between tip of snout and eye, posterior just before orbit; diameter of orbit equal to greatest preopercular width, about twice interorbital.

Origin of dorsal slightly in advance of pectoral base; spinous portion two or three times length of soft part; fin obtusely pointed posteriorly; spines gradually increasing in length posteriorly; first spine three-fifths length of second which equals eye diameter; last spine slightly less than post-orbital part of head; longest soft rays greater than distance between orbit and base of pectoral; membrane extending beyond tips of spines, incised along leading edges of spines; notch reaching three-fourths of distance to base of second and third spines; notch decreasing in depth thereafter to last spine before which it reaches one-third distance to base.

Anal fin inserted opposite tenth dorsal spine; shape similar to dorsal; first spine half of second; third spine longest, subequal to last dorsal spine; longest soft anal ray equal to distance between orbit and base of pectoral; membrane notched behind first spine.

Pectoral rounded; inserted just below midline; lowest four to six rays free from membrane in distal halves; lowest ray with four branches in adults and sub-adults (over 50 mm.); next five rays with four to nine branches each.

Pelvics inserted before pectoral base; spine longer than third anal spine, bound to first soft ray; first ray thickened, bifid almost to base, elongated, reaching at least to anal origin; three inner rays bifid, not thickened or elongated.

Caudal rounded.

Head naked laterally and dorsally before preopercle; nape, preopercle, and opercle with cycloid scales; preopercle with ten or eleven forwardly sloping, oblique scale rows; seven scales in horizontal series across widest part of preopercle; opercle with a few large scales about three or four times size of those on preopercle; scales above upper lateral line cycloid; first thirteen scales of upper lateral line cycloid; curved line from tenth lateral line scale to third scale behind center of axilla and to third scale before vent marking posterior boundary of cycloid scales; all other body scales ctenoid; dorsal and anal sheaths cycloid; ten predorsals.

Color (in alcohol) of head, body, and fins blackish; two short postorbital bars not running on to scaled area of preopercle; many of body scales with light center; margin of dorsal membrane dusky, lighter than basal portion; caudal with narrow light margin.

This description is based primarily upon USNM 147530 (Red Sea) amplified by Rüppell's descriptions and the notes of Dr. Zilch.

Material examined: Red Sea (1).

Range: Apparently restricted to the Red Sea.

Plesiops multisquamata new species

Plesiops nigricans Gilchrist and Thompson, 1911, So. African Mus., Ann. 11: 37; 1917, Durban Mus., Ann. 1: 335; Barnard, 1927, So. African Mus., Ann. 21: 494; Smith, 1949, Sea-Fishes So. Africa, p. 186, fig. 410; 1952, Ann. and Mag. Nat. Hist. XII, 5: 141, pl. 9.

[*non*] *Plesiops nigricans* Rüppell, 1828, Atlas Reise nördl. Afrika, Fische, p. 15.

Diagnosis: Dorsal spines XII; lateral line 25–30 + 13–19; mid-lateral scales 28–34; transverse series 5/1/10–12; total gill rakers on first arch 16–19; two lowest pectoral rays with more than two branches each; standard length of adults well beyond 100 mm.; total length commonly over 200 mm.; opercle without dark ocellus; small blue spots over head and body; fins blackish.

Description: Dorsal XII, 7; pectoral 21–23; pelvic I, 4; anal III, 8; gill rakers 4–6 + 11–13; total length 220–245 mm.

(The following is based primarily upon Smith, 1952.) Body slightly compressed; dorsal profile convex, rising gradually from snout, feebly concave over nape; ventral profile convex; snout subequal to eye; mouth somewhat oblique; maxilla reaching posterior level of orbit; posterior nostril close to orbit, anterior nostril with short tube.

Dorsal origin above pectoral base or opercle; fin obtusely pointed posteriorly; spines increasing in size posteriorly; first spine four-fifths second; second spine subequal to eye diameter; longest soft ray about twice length of longest spine; membrane extending beyond tips of spines; membrane incised along forward edge of spines almost to base of second to eighth; notch decreasing in depth beyond that spine.

Anal origin opposite ninth or tenth dorsal spine; shape similar to that of dorsal; first spine little over half length of second which is four-fifths of last; third spine slightly shorter than last dorsal spine; longest anal ray subequal to longest dorsal ray; membrane

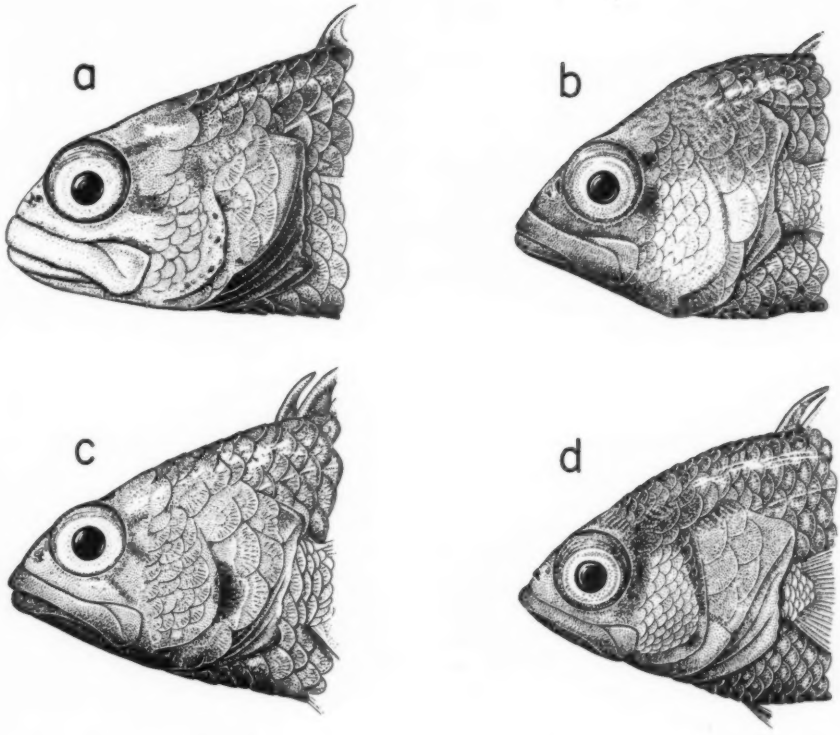

FIG. 3. Differences in head shape, scalation, and coloration in four species of *Plesiops*. *a*, *P. coeruleolineatus* (× 3); *b*, *P. oxycephalus* (× 1.5); *c*, *P. corallicola* (× 1.5); *d*, *P. nigricans* (× 3).

not (?) reaching beyond tips of spines, feebly notched.

Pectorals rounded; inserted just below midline of side; lowest seven to ten rays free from membrane in distal halves or three-quarters; lowest four rays with at least three branches each and usually six or more; next four rays above with eight to twelve branches.

Pelvics inserted below pectoral base; spine slightly shorter than longest dorsal spine, first ray thickened, bifid, reaching anal origin or beyond; inner rays not thickened.

Head naked laterally before preopercle and dorsally before the opercle; preopercle with 4 or 5 vertical rows of scales; 5 to 7 scales in horizontal series across widest part of preopercle; anterior body scales cycloid, becoming ctenoid below fifth dorsal spine (approximately tenth lateral line scale); scales above posterior half of upper lateral line ctenoid; six or seven predorsals; dorsal and anal with low sheath of cycloid scales.

Color of body and fins blackish, slightly lighter on belly; indistinct darker area at origin of upper lateral line; small blue spots scattered over head, body, and fins.

Remarks: The specimens identified by Gilchrist and Thompson (1911, 1917), Barnard (1927), and Smith (1949, 1952) as *nigricans* are all from the Natal coast. They differ sharply from true *nigricans* in scale counts as the following comparison shows.

		UPPER LATERAL LINE	MID-LATERAL SCALES	TRANSVERSE SCALES; LATERAL LINE TO ANAL
nigricans	Rüppell's figure	23	24–27	8
nigricans	Second Rüppell specimen	19	23	...
nigricans	USNM 147530 (Red Sea)	19	...	9
multisquamata	Gilchrist & Thompson (1911)	27	...	...
multisquamata	Barnard (1927)	28–30	...	10–11
multisquamata	Barnard (personal communication)	25–29	30–33	...
multisquamata	Smith (1949)	25–28	28–30	12
multisquamata	Smith (1952)	27	33–34	12

Data on the second Rüppell specimen were supplied by Dr. Zilch. Barnard (personal communication) re-examined the fishes seen by himself (1927) and by Gilchrist and Thompson (1911). At most six Natal specimens are included in the table.

If the two groups are treated as one species, the ranges of variation in upper lateral line (12), mid-lateral (12), and transverse scales (4) far exceed observed ranges in other species (see Table 3). In fact thay would exceed the ranges for all other species combined.

The high scale counts separate *multisquamata* from its congeners. The coloration (pectoral not bicolored; opercle without ocellus) is different from that of the large Indo-Pacific form, *corallicola*, while its size sets it off from the three small species, *coeruleolineatus*, *oxycephalus*, and *cephalotaenia*.

Material examined: None.

Holotype: Specimen 220 mm. total length, described by Smith (1952) from Natal and figured in Smith's plate 9.

Admittedly it is bad practice to describe a new form without actually having material at hand. Fortunately the detailed description and figure provided by Smith (1952) make identification possible and furnish a type.

Range: As yet known only from the coast of Natal.

Plesiops corallicola Bleeker

Figs. 1*a*, 2*b*, *c*, 3*c*

Plesiops corallicola Bleeker, 1853, Nat. Tijd. Ned. Indië 4: 280—Priamam, Sumatra; 1857, *op. cit.*, 13: 479; 1860, Soc. Sci. Indo-Neerl., Act. 8 (Sumatra): 35; 1865, Ned. Tijd. Dierk. 2: 279; Günther, 1861, Cat. Fishes Brit. Mus. 3: 364; 1873, Fische Südsee 1: 87, pl. 58, fig. B; Kner, 1865, Reise Novara, Fische, p. 214; Vaillant, 1889, Soc. Philom., Bul. VIII, 1: 58.

Plesiops nigricans (not of Rüppell). Bleeker, 1875, Akad. Wetens. Amsterdam, Verh. 15 (Pseudochr.): 27, pl. 3, fig. 3 (part); Day, 1878, Fishes India, p. 128, pl. 31, fig. 5; 1889, Fauna Brit. India, Fishes, 2: 79, fig. 79; Vaillant, 1889, Soc. Philom., Bul. VIII, 1: 58; Boulenger, 1895, Cat. Fishes Brit. Mus. 1: 340 (part); Jordan and Richardson, 1908, U. S. Bur. Fish., Bul. 27: 257; Weber, 1913, Siboga Exped., Fische, p. 212; de Beaufort, 1913, Bijdr. Dierk. 19: 112; Fowler, 1928, Bernice P. Bishop Mus., Mem. 10: 188; Weber and de Beaufort, 1929, Fishes Indo-Austr. Arch. 5: 375; Fowler and Bean, 1930, U. S. Natl. Mus., Bul. 100, 10: 313; Herre, 1936, Field Mus. Nat. Hist., Zool., 21: 163; Fowler, 1938, Hong Kong Nat. 9: 59, fig. 18; Schultz, 1943, U. S. Natl. Mus., Bul. 180: 112 (part).

Pharopteryx nigricans (not of Rüppell). Jordan and Seale, 1906, U. S. Bur. Fish., Bul. 25: 260.

Plesiops nakaharae Tanaka, 1917, Zool. Mag. 29: 199—Prov. Shima or Kii, Japan.

Pharopteryx nakaharae Tanaka, 1935, Fishes Japan, 2nd. ed., p. 497, pl. 137, fig. 383

Pseudochromichthys riukianus Schmidt, 1931, Pac. Comm. Acad. Sci. U. S. S. R., Trans. 2: 180—Riukiu Islands.

Although the original description of *corallicola* (Bleeker, 1853) does not mention an opercular ocellus, Bleeker subsequently stated

(1875: p. 27) that *nigricans*, with which he synonymized *corallicola*, has a conspicuous yellow-ringed, dark spot on the opercle (see pl. 3, fig. 3 in the latter work). It may be assumed that this later description applies to *corallicola* as true *nigricans*, which has no opercular ocellus, does not occur in the East Indies, the origin of all of Bleeker's material.

Bleeker thought that the ocellus, found only in the larger of his specimens, was an adult characteristic. But, since he included *coeruleolineatus* in the synonymy of *nigricans*, it may also be assumed that his "juveniles" were really adult *coeruleolineatus*. (Compare size ranges of *coeruleolineatus* and *corallicola*.)

Günther (1861) agreed with Bleeker that *corallicola* was probably identical to *nigricans* Rüppell although Günther still maintained the former (figured by him with an opercular ocellus) as a distinct species in Fische der Südsee (1873). All subsequent authors (e.g., Day, 1878; Boulenger, 1895; Jordan and Seale, 1906; Weber and de Beaufort, 1929) have incorrectly called the ocellated species *nigricans*.

Plesiops nakaharae Tanaka agrees with *corallicola* in length, coloration, and counts (gill rakers 14, lateral line 19+13–14, dorsal XII, 7). There appears to be no reason for recognizing *nakaharae* as a distinct form.

Diagnosis: Dorsal spines normally XII; lateral line 17–21+11–16; mid-lateral series 21–25; scales in transverse series 3–4/1/8–10; total gill rakers on first arch 13–17; lowest pectoral rays with at least three and usually four or more branches, next ray with at least four branches in all specimens over 45 mm.; standard length commonly above 70 mm.; maximum total length about 140 mm.; opercle with a dark, light-rimmed ocellus; preopercle not crossed by black bars; head and body often with minute bluish or whitish spots; caudal blackish, occasionally with a narrow light margin.

Description: Dorsal XII–XIII, 6–7; pectoral 19–22; pelvic I, 4; anal III, 8; gill rakers 4–7+8–11, total 13–17; standard length 10.0–120.0 mm.; head 2.56–2.96 (mean 2.73 ±0.02; N=30); depth 2.88–3.56 (mean 3.21 ±0.04; N=23).

Body elongate (juveniles) to oval (adults), compressed; dorsal profile convex; rostrodorsal line rising gradually, feebly curved, forming a 30 degree angle with mid-lateral line; ventral profile weakly convex, sloping in straight line from snout to pelvics; snout bluntly pointed in profile, shorter than eye; mouth slightly oblique; maxilla reaching behind orbit; posterior nostril just before orbit, equidistant from orbit and anterior tubulated nostril; diameter of orbit equal to its horizontal distance from end of preopercle, one and one-half to twice width of interorbital.

Dorsal origin above pectoral base or opercle; fin pointed posteriorly; spines increasing in size to tenth; first spine about three-fourths second; second equals distance between orbit and end of preopercle; longest soft ray more than twice length of last spine, equal to or greater than distance between orbit and pectoral base; membrane extending beyond tips of spines; membrane incised along forward edge of spines almost to base of second to fourth spines; notch decreasing gradually in depth posteriorly but reaching halfway to base at front of last spine.

Anal origin opposite tenth or eleventh dorsal spine; shape similar to that of dorsal; first spine two-thirds of second which is two-thirds of last; third spine slightly shorter than last dorsal spine; longest soft anal subequal to longest soft dorsal ray; membrane extending beyond tips of spines and notched half to two-thirds of distance to base before second and third spines.

Pectoral rounded; inserted just below midline of side; lowest four to seven rays free in distal halves or three-quarters; lowest four rays with at least four branches each in all adults and sub-adults (over 40 mm.), next four rays with four or more branches each.

Pelvics inserted before base of pectoral; spine subequal to longest dorsal spine; first ray bifid to basal third of spine, thickened,

reaching between vent and third anal spine; inner rays bifid, not thickened.

Caudal rounded.

Head naked above and laterally anterior to preopercle; nape, preopercle, and opercle with cycloid scales; scales of preopercle in seven to nine forwardly sloping oblique rows; five scales in horizontal series across widest part of preopercle; opercle with six large scales, each about twice depth of preopercular scales;

TABLE 3

SUMMARY OF CERTAIN COUNTS MADE ON SPECIES OF THE GENUS *Plesiops*

NUMBERS IN THE BODY OF THE TABLE REFER TO INDIVIDUALS

(Symbols (+) represent the range of variation determined from the literature in the instances in which little or no material was available)

		P. nigricans	*P. multisquamata*	*P. cephalotaenia*	*P. oxycephalus*	*P. coeruleolineatus*	*P. coralicola*
Dorsal fin	X					1	
	XI			1		79	
	XII	1	+	18	8	3	64
	XIII						1
	6					6	1
	7	1	+	19	8	76	64
Anal fin	III	1	+	18	8	82	59
	7			1	1	1	
	8	1	+	17	7	81	59
Pectoral fin, total rays	17				1		
	18			4	1		
	19			13	3	1	1
	20	+		2	4	6	14
	21	+	+			29	41
	22	+	+			37	9
	23		+			12	
Gill rakers, lower limb of first arch	5					1	
	6					5	
	7					42	
	8			2	2	23	11
	9			6	5	5	26
	10			5	1	1	14
	11		+	3			1
	12	1	+				
	13		+				
Total gill rakers, first arch	9					1	
	10					3	
	11					25	
	12					27	
	13			2		17	4
	14			4	3	3	12
	15			3	3	1	23
	16		+	4	2		11
	17		+	3			2
	18	1	+				
	19		+				

body scales cycloid anteriorly, ctenoid behind; all scales above upper lateral line cycloid; below lateral line scales cycloid before a line running from tenth to twelfth lateral line scale, curving forward several scales in mid-line, then backward to base of soft anal; about eight predorsals; dorsal and anal fins with low sheath of cycloid scales.

Color (in alcohol) dark brown or blackish; head and body often with small bluish spots;

TABLE 3 (Continued)

		P. nigricans	*P. multisquamata*	*P. cephalotaenia*	*P. oxycephalus*	*P. cerulealineatus*	*P. coralliicola*
Upper lateral line scales	17			1			1
	18			11	5	19	18
	19	+		5	2	41	27
	20	+			1	18	15
	21	+		1		1	1
	22	+					
	23	+					
	24						
	25		+				
	26		+				
	27		+				
	28		+				
	29		+				
	30		+				
Lower lateral line scales	6			2		2	
	7			4	1	2	
	8			5	1	1	
	9			2	2	19	
	10			3		18	
	11			2	2	18	3
	12			1	2	14	6
	13		+			5	20
	14	+	+				27
	15	+	+				4
	16	+	+				3
	17	+	+				
	18		+				
	19		+				
Mid-lateral scales	21			1		4	1
	22			1	1	34	4
	23	+		4	3	20	22
	24	+		9	4	4	20
	25	+		1			4
	26	+					
	27	+					
	28		+				
	29		+				
	30		+				
	31		+				
	32		+				
	33		+				
	34		+				

a squarish black bar at upper posterior border and one just below center of posterior border of orbit, neither reaching preopercle; occasionally a narrower oblique bar from beneath eye to posterior quarter of maxilla; lower half of opercle with a round blackish or dark bluish spot, usually with a narrow light border; ventrally gill membranes blackish; fins dark; pectoral usually with a light tip (orange in life); dorsal membrane black, narrowly margined with light gray or white behind anterior fifth; anal black, soft portion with a narrow white or clear margin; caudal with narrow white margin; pelvics dark, without spots.

Material examined: Philippine Islands: Sulu Islands (1), Maculabo (2), Mindoro (2). Waigieu (1). New Hebrides (3). Fiji Islands (1). Tonga Islands: Vavau (1). Samoan Islands: Tutuila (10). Phoenix Islands: Hull (5), Canton (5). Caroline Islands: Yap (4), Angaur (4). Mariana Islands: Guam (19), Rota (5), Saipan (8). Marshall Islands: Rongelap (4), Bikini (6). East Indian Archipelago (1)

Range: From the Bay of Bengal southeastwards to Samoa and Tonga and northwards to southern Japan.

Plesiops coeruleolineatus Rüppell

Figs. 2*a*, 3*a*

Plesiops coeruleolineatus Rüppell, 1835, Neue Wirbelt., Fische, p. 5, pl. 2, fig. 5—Massaua, Red Sea; Bleeker, 1853, Nat. Tijd. Ned. Indië, 4: 116; Günther, 1861, Cat. Fishes Brit. Mus. 3: 363; Klunzinger, 1871, Zool.-Bot. Ges. Wien, Abh. 21: 517.

Plesiops coeruleolineatus Smith, 1952, Ann. and Mag. Nat. Hist., XII, 5: 143, pl. 10, fig B, text fig. 1.

Plesiops melas Bleeker, 1849, Batav. Genoot, Verh. 22 (Bali): 9—Boleling, Jordan and Richardson, 1908, U. S. Bur. Fish., Bul. 27: 257; Snyder, 1912, U. S. Natl. Mus., Proc. 42: 498; Weber, 1913, Siboga Exped., Fische, p. 213; Weber and de Beaufort, 1929, Fishes Indo-Austr. Arch. 5: 378, fig. 91; Herre, 1936, Field Mus. Nat. Hist., Zool., 21: 163; Smith, 1949, Sea Fishes So. Africa, p. 187; Marshall, 1950, Raffles Mus., Bul. 22: 175.

Pharopteryx melas Jordan and Seale, 1906, U. S. Bur. Fish., Bul. 25: 261; Ogilby, 1913, Queensland Mus., Mem. 2: 84.

Plesiops nigricans (not of Rüppell; part). Bleeker, 1875, Akad. Wetens. Amsterdam, Verh. 15 (Pseudochr.): 27; Day, 1878, Fishes India, p. 127; Boulenger, 1895, Cat. Fishes Brit. Mus. 1: 340; Schultz, 1943, U. S. Natl. Mus., Bul. 180: 112.

Plesiops semeion Tanaka, 1917, Zool. Mag. 29: 200—Tanabe, Kii Prov., Japan.

Pharopteryx semeion Tanaka, 1935, Fishes Japan, 2nd ed., p. 500, pl. 137, fig. 382.

Shortly after describing *melas*, Bleeker (1853) realized that it was a synonym of *coeruleolineatus* Rüppell. Later (1875) he thought that the latter was merely the juvenile of what is now known to be *corallicola*. However, Jordan and Seale (1906) clarified the distinctions between these two species and no author since 1906 has followed Bleeker. Schultz's designation (1943) is the result of a mistaken identification.

Günther (1861) agreed with Bleeker that *melas* is identical to *coeruleolineatus* Rüppell. Except for Klunzinger (1871), no subsequent author had material from the western Indian Ocean and all recognized *melas* Bleeker until Smith (1952), who reaffirmed the conclusion of Bleeker and Günther.

Plesiops semeion Tanaka agrees with *coeruleolineatus* in counts (gill rakers 11, lateral line 20 + 12, dorsal XI, 7). The coloration details of the dorsal membrane are identical to those of *coeruleolineatus*. Tanaka's fish had six broad, dark crossbands on the body. Although these are not usually found in *coeruleolineatus*, occasional individuals have obscure indications of such markings.

Diagnosis: Dorsal spines normally XI; lateral line 18–21 + 6–13; mid-lateral scales 21–24; scales in transverse series 2–3/1/8–10;

total gill rakers on first arch 9–14; two lowest pectoral rays with two branches each; standard length under 70 mm.; opercle without ocellus; head and body without bluish or whitish spots; caudal black, usually with a faint, narrow, light crescentric band submarginally.

Description: Dorsal XI, 6–7; pectoral 19–23; pelvic I, 4; anal III, 8; gill rakers 3–6 + 5–10; total length up to 79 mm.; standard length to 61 mm.; head 2.48–2.90 (mean 2.61 ± 0.02; N = 27); depth 3.02–3.67 (mean 3.26 ± 0.03; N = 24).

Body compressed, oblong; dorsal profile convex; rostro-dorsal line feebly curved, forming a 30 degree angle with mid-lateral line; ventral profile weakly convex, sloping in straight line from snout to pelvics; snout bluntly pointed in profile, shorter than eye; mouth slightly oblique; maxilla reaching behind orbit; posterior nostril just before orbit, equidistant from orbit and anterior, tabulated nostril; diameter of orbit subequal to its horizontal distance from end of preopercle, approximately twice interorbital width.

Dorsal origin above pectoral base; fin bluntly pointed posteriorly; base of spinous portion two and one-half to three times length of soft dorsal; spines increasing in length gradually to last; first spine three-fourths second; second equal to eye diameter; last spine slightly less than post-orbital part of head; longest soft ray greater than distance between orbit and base of pectoral; membrane extending beyond tips of spines; membrane incised to basal third along leading edge of second to sixth spines; the notch decreasing in depth posteriorly, finally reaching only one-fifth of distance to base before last spine.

Anal origin opposite ninth or tenth dorsal spine; shape similar to that of dorsal; first spine half length of second, the latter about five-sixths the third; last spine about five-sixths length of last dorsal spine; longest soft ray equal to longest soft dorsal ray; membrane incised to basal third of second anal spine, scarcely notched before third spine.

Pectoral rounded; inserted just below midline; lowest four to seven rays free from membrane in distal halves or three-quarters; three lowest rays each with two branches; next three to five rays with two to four branches each; largest specimens (ca. 50 mm.) sometimes with five branches on each of several middle rays.

Pelvics inserted opposite or slightly before pectoral base; spine longer than third anal spine; first ray thickened, bifid beyond level of center of spine, elongated, reaching second to fourth soft anal ray; three inner rays bifid, not thickened.

Caudal rounded.

Head naked on side to preopercle, naked above to point opposite end of preopercle or slightly before; cycloid scales covering preopercle, opercle, and nape; scales of preopercle in eight forwardly sloping oblique rows; five scales in horizontal series across widest part of preopercle; opercle with six large scales, each about twice depth of preopercular scales; scales above upper lateral line cycloid; occasionally two or three above end ctenoid; scales before line connecting fifth lateral line scale and upper end of pectoral base cycloid; scales below and anterior to line connecting lower end of pectoral base with anus cycloid; all other body scales ctenoid; anterior limit of ctenoid scalation on abdomen sometimes extending forward two or three scale rows; about seven predorsals; anal and soft dorsal with low sheath of cycloid scales.

Coloration (in alcohol) dark brown or black; some of body scales with dark tips; a squarish black bar at upper posterior corner and a second at center of posterior border of orbit, neither reaching preopercle; a narrow black stripe from below center of orbit, running above maxilla to its end; occasionally a few small black spots along border of preopercle; ventrally gill membranes black; fins blackish; anteriorly basal third of dorsal fin black followed distally by a narrow clear line, a slightly wider dusky band, and a broader

marginal light band (one-third fin depth); longitudinal pattern of dorsal slopes upward posteriorly leaving only a narrow light margin on soft dorsal; some individuals with sloping blue line in basal black zone of dorsal; juveniles with only a terminal light band on dorsal; anal and caudal usually with narrow light margins; occasionally caudal with a faint, narrow (equal to width of lowest post-orbital black streak), crescentric light band across beginning of distal third of fin; pectoral unmarked; membrane of pelvics spotted with black.

The oblique blue lines on the dorsal and anal membranes, to which the specific name refers, do not occur on all individuals. Of those examined, only fishes from southeastern Luzon and Mindoro had these stripes.

Material examined: Riu Kiu Islands: Okinawa (3). Philippine Islands: Batan (47), Bubuan (1), Busuanga (1), Luzon (35), Maculabo (24), Masongas (2), Mindanao (1), Mindoro (6), Negros (5), Pilas (3), Samar (1), Sirinao (1). Borneo: Pulo Bakkungaan Kechil (14). Karakelang Islands: Beo (1). Sanghir Islands (5). Morotai (1). Celebes: Tobea Island (1). Buru (6). Waigieu (4). New Hebrides: Malo (8). Solomon Islands: Bougainville (3). Samoan Islands: Tutuila (56). Caroline Islands: Yap (2). Mariana Islands: Guam (22), Saipan (12). Marshall Islands: Bikini (24), Eniwetok (18), Kwajalein (4), Rongelap (68). Madagascar (1). Red Sea (8).

Range: From the Red Sea and east coast of Africa through the Indo-Pacific northwards to southern Japan, and eastwards to the Marshall Islands and Samoa.

Plesiops cephalotaenia new species
Figs. 1*b*, 4

Diagnosis: (Counts, size, and proportions of holotype in parentheses in diagnosis and description.) Dorsal spines normally XII; lateral line 17–21 + 6–12 (19 + 12); mid-lateral scales 21–25 (23); scales in transverse series 2–3/1/8–9 (2½/1/9); two lowest pectoral rays with two branches each; lower pectoral rays free in distal halves or at tips only; standard length under 70 mm.; black stripe from center of orbital border to end of opercle, but no opercular ocellus; caudal dark, without crescentric, light band.

Description: XI–XII, 7 (XII, 7); pectoral 18–20 (19); pelvic I, 4 (I, 4); anal III, 7–8 [Only one of the 20 seen had 7 soft anal rays.] (III, 8); gill rakers 5–6 + 8–11 (5 + 9), total 13–17; standard length 22.5–52.5 mm. (48.5 mm.); head 2.34–2.84 (2.76) (mean 2.53 ± 0.03; N = 17); depth 2.43–2.94 (2.57) (mean 2.76 ± 0.04; N = 14).

Body oval, compressed; dorsal profile rising in a curved line to dorsal origin; line from snout to dorsal making a 35 degree angle with mid-lateral line; ventral profile convex; snout-pelvic line straight, sloping slightly; snout obtuse in profile, shorter than eye; mouth almost horizontal; maxilla reaching perpendicular from posterior border of orbit; posterior nostril close to orbit, equidistant from orbit and anterior, tubulated nostril; diameter of orbit equal to distance between orbit and angle of preopercle or slightly less, more than twice interorbital.

Dorsal origin above base of pectoral; fin bluntly pointed posteriorly; base of spinous portion about three times base of soft dorsal; spines increasing in length to last; first spine about half length of second; second less than eye diameter; last spine subequal to post-orbital length of head; longest soft ray subequal to post-orbital part of head; membrane extending beyond tips of spines, incised halfway to base along leading edge of each of second to tenth spines.

Anal origin opposite tenth dorsal spine; shape similar to that of dorsal; first spine half length of second, the latter two-thirds length of last spine; third spine subequal to longest dorsal spine; longest soft anal ray equal to distance between orbit and end of pectoral base; membrane of spinous anal more deeply incised than that of dorsal.

Pectoral rounded; inserted just below mid-line; rays free near tips only or in distal halves;

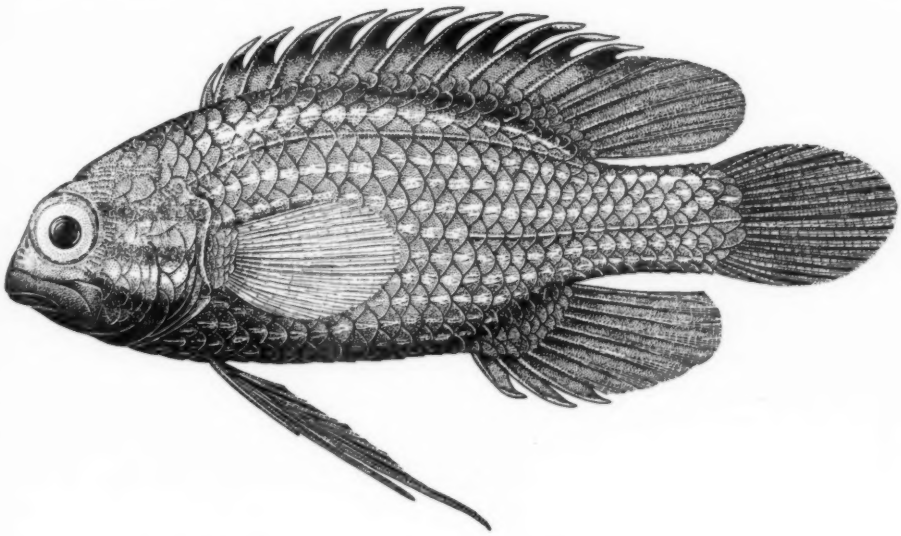

FIG. 4. *Plesiops cephalotaenia* new species. Holotype CNHM 44708 (× 2).

two lowest rays with two branches each; fifth ray above ventral edge with four branches; all higher rays with two to four branches each.

Pelvics inserted before pectoral base; spine equal to or slightly shorter than last anal spine; first ray thickened, bifid beyond distal half of spine, elongated, reaching first or second soft anal ray; three inner rays bifid, not thickened.

Caudal rounded.

Head naked to level of preopercle; cycloid scales covering nape, preopercle, and opercle; scales of preopercle in five to seven forwardly sloping oblique rows; three or four scales in horizontal series across widest part of preopercle; opercle with six large scales, each about twice depth of preopercular series; scales above upper lateral line cycloid at least to tenth or twelfth lateral line scale; scales before line connecting third or fifth lateral line scale with top of pectoral base cycloid; scales before line connecting bottom of pectoral base with pelvic insertion cycloid; posterior limit of cycloid breast scalation occasionally one or two scale rows behind pelvic insertion; all other body scales ctenoid; six or seven predorsals; anal and soft dorsal with low sheath of scales, those of anal mostly ctenoid.

Coloration (in alcohol) dark brown or black, body with six to nine obscure dark longitudinal stripes, each covering peripheral thirds of two adjacent scale rows; post-orbital part of head with three black stripes; one from upper corner of orbit, interrupted above preopercle, continuing as a bar near upper border of opercle; middle stripe horizontal, continuous from center of orbit to end of opercle; lower stripe sloping slightly, usually continuous from lower corner of orbit to angle of preopercle; gill membranes black; fins blackish; spinous dorsal with marginal white band narrower than post-orbital stripes, bordered proximally by intense black band; caudal with very narrow white margin; pelvics blackish with small dark spots.

The markings of the head are faded in several of the paratypes.

A female (USNM 146466), swollen with ripe ova, measures only 35.0 mm.

Remarks: Plesiops cephalotaenia appears to be most closely related to *oxycephalus*. It differs from the latter in having only three (rarely four) scales across the preopercle instead of five or six, in having a post-orbital black stripe crossing the preopercle and opercle, and in the color of the pelvics, caudal, and dorsal fins. The steeper rostro-dorsal profile and the presence of ctenoid scales at or immediately behind the insertion of the pelvics distinguish both of these forms from the remainder of the genus.

Material: Holotype, Chicago Natural History Museum no. 44708 from Sitankai, Sulu Archipelago, Philippine Islands. Collected by A. W. Herre. *Paratypes:* Philippine Islands: Maculabo (1, USNM 146467), Mantacao (1, USNM 146462), Masbate (7, USNM 146466), Rapu Rapu (1, USNM 146460), San Miguel (1, USNM 146464), Sitankai (3, CNHM 47293), Tara (1, USNM 151323). Borneo: Darvel Bay (1, USNM 146469). Buru (2, USNM 162704). New Guinea: Tanamara Bay (1, USNM 123384).

Range: Philippine Islands from Mindoro Strait and San Miguel Bay (southeastern Luzon) to eastern Borneo and New Guinea.

Probably occurring throughout the Indo-Australian Archipelago east of the Sunda Shelf.

Plesiops oxycephalus Bleeker

Figs. 1*c*, 3*b*

Plesiops oxycephalus Bleeker, 1855, Nat. Tijd, Ned. Indië, 8: 320—Batu Islands; 1857. *op. cit.* 12: 234; 1865, Ned. Tijd. Dierk. 2: 279; 1875, Akad. Wetens. Amsterdam, Verh. 15 (Pseudochr.): 29; 1877, Atlas Ichthy. 9: pl. 389, fig. 7; Günther, 1861, Cat. Fishes Brit. Mus. 3: 364; Vaillant, 1889, Soc. Philom., Bul. VIII, 1: 57; Boulenger, 1895, Cat. Fishes Brit. Mus. 1: 341; Weber and de Beaufort, 1929, Fishes Indo-Aust. Arch. 5: 377; Fowler and Bean, 1930, U. S. Natl. Mus., Bul. no. 100, 10: 316.

Smith (1952) suggests, after a study of the literature, that *oxycephalus* may be a synonym of *coeruleolineatus* Rüppell. These two forms, however, are readily distinguished by coloration, counts, head shape, and scalation.

Diagnosis: Dorsal spines XII; lateral line 18–20 + 7–12; mid-lateral scales 22–24; scales in transverse series 2–3/1/8–9; total gill rakers on first arch 14–16; two lowest pectoral rays with one or two branches each; lower pectoral rays free at tips or in distal third only; standard length to 65 mm.; total length up to 97 mm. (Bleeker, 1855); opercle yellowish, without ocellus; body scales usually with faint light spots; caudal with broad, orange, crescentic band medially.

Description: Dorsal XII, 7; pectoral 17–20; pelvic I, 4; anal III, 8; gill rakers 5–7 + 8–10; standard length to 65 mm.; head 2.32–2.51 (mean 2.40 ± 0.02; N = 8); depth 2.80–3.16 (mean 2.91 ± 0.05; N = 7).

Body compressed, oblong; dorsal profile convex; rostro-dorsal profile moderately steep, bent at nape, making 35 degree angle with mid-lateral line; ventral profile convex, scarcely sloping from snout to pelvics; snout bluntly pointed in profile, slightly shorter than eye; mouth horizontal or somewhat oblique; maxilla reaching posterior level of orbit or just beyond; posterior nostril just before orbit, equidistant from orbit and anterior, tubulated nostril; diameter of orbit less than its distance from end of preopercle, about twice interorbital width.

Dorsal origin above tip of opercle; pointed posteriorly; base of spinous part about three times length of soft part; spines increasing in size to tenth; first spine about two-thirds length of second which is subequal to eye; last spine subequal to distance between orbit and end of preopercle; longest soft ray equal to post-orbital part of head; membrane extending beyond tips of spines, notched along front edge of spines to basal third of anterior spines; notch becoming shallower posteriorly, reaching to center of last spine.

Anal origin opposite ninth dorsal spine; shape similar to that of dorsal; first spine three-fifths second; second spine five-sixths

last, which is slightly shorter than last dorsal spine; longest soft ray equal to longest soft dorsal ray; membrane extending beyond tips of anal spines, notched before second and third spines.

Pectoral rounded; inserted just below midline; lowest ray free in distal half, next three or four rays at tips only; lowest four rays with one or two branches each; next four rays with two to four rays each.

Pelvics inserted slightly in advance of pectoral base; spine equal to last anal spine; first ray bifid to center of spine, thickened, elongated, reaching anal origin or first soft anal ray; inner rays bifid, not thickened.

Caudal obtusely pointed.

Head naked laterally to preopercle and dorsally to above end of preopercle; cycloid scales covering nape, preopercle, and opercle; scales of preopercle in eight forwardly sloping oblique rows; five or six scales in horizontal series across widest part of preopercle; opercle with six large scales, each twice depth of preopercular scales; scales above upper lateral line all cycloid or ctenoid posterior to twelfth or thirteenth lateral line scale; body scales anterior to line between sixth or seventh lateral line scale and top of pectoral base cycloid; scales before line connecting bottom of pectoral base with point two scales behind pelvic insertion cycloid; all other body scales ctenoid; nine predorsals; anal and soft dorsal with low sheath of mostly ctenoid scales.

Color (in alcohol) dark brown; a small black spot at upper posterior border and a larger spot behind center of orbit; lower two-thirds of opercle yellow; preopercle occasionally yellowish; gill membranes blackish; pectoral uniformly dark dusky; dorsal membrane dark brown basally bordered by cream-colored band; light band occupying distal half of membrane up to sixth or seventh spine, narrowing posteriorly to thin margin over soft dorsal; anal blackish with a thin light margin; pelvic same light brown or yellowish as opercle; caudal with a narrow light margin, bordered proximally by a broader black band, preceded in turn by a broader orange, crescentric band equal in width to pupil; basally caudal with a black triangle.

The coloration varies. The anterior half of the heads of two Celebes fishes (USNM 146471) is densely dotted with dark brown; these small spots are not present on the other specimens. Five individuals (USNM 146451, 146461, 162704) from the Philippines and the Moluccas have 5 to 7 vertical dark bands made up of spotted body scales.

The entire sample is uniform in those color characteristics distinguishing *oxycephalus* from *cephalotaenia*, i.e., the yellow opercle, the light pelvics, the broad caudal crescent, and the unstriped preopercle.

Material examined: Philippine Islands: Bisucay (1), Luzon (1), Pangasinan (1). Celebes: Togean Island (2). Buru (3). New Hebrides: Efate Island (1).

Range: From western Sumatra to the New Hebrides, northwards to Luzon.

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A New Family of Spiders of the Sub-order Hypochilomorphae

R. R. FORSTER[1]

THE SUB-ORDER HYPOCHILOMORPHAE was established by Petrunkevitch in 1933 to include those spiders with diaxial chelicerae which also possessed four lung books. Three species are known viz. *Hypochilus thorelli* Marx, from North America, *Ectatosticta davidi* Simon, from Tibet, and *Ectatosticta troglodytes* (Higg. and Pet.), from Tasmania, which are all included in the family Hypochilidae. The establishment of this sub-order has not met with general agreement among present-day arachnologists, many of whom still group these spiders with the two-lunged cribellate spiders. The occurrence of the two species recorded in the present paper, which do not possess a cribellum seems to strengthen Petrunkevitch's case for the separation of these spiders into a separate sub-order.

The three previously known species share many characters in common. They are long-legged, sedentary spiders which construct extensive webs. They possess relatively small, vertical chelicerae and the poison glands do not extend into the cephalothorax. The genital bulb of the male is terminal, the heart is supplied with four pairs of ostia and they all possess a cribellum.

The two species described below although they possess diaxial chelicerae, two pairs of lung books and four pairs of ostia, differ considerably in other characters from previously known species. In general appearance and habit they resemble lycosid spiders. They are vagrant in habit, hunting their prey on the forest floor. They do not appear to make any webs or to use silk in any way to snare their food. The chelicerae are strong and directed forward and are provided with large poison glands which extend well into the cephalothorax. The genital bulb of the male is inserted near the middle of the ventral surface of the tarsus of the pedipalp and there is no cribellum present.

In view of the striking differences shown by these two species, particularly the absence of a cribellum, I have considered it advisable to establish a new family for their reception.

Sub-order HYPOCHILOMORPHAE Petrunkevitch, 1933

Family **GRADUNGULIDAE** fam. nov.

Ecribellate spiders with non-segmented abdomen. Two pairs of lung books. Diaxial chelicerae, lacking lateral condyles, with endocephalic poison glands. Maxillary lobes well developed, multicellular maxillary glands with ducts opening from a sieve. Six spinnerets with colulus. Three tarsal claws. Tarsus of female pedipalp with strong claw, genital bulb of male pedipalp not terminal. Eight eyes in two rows.

Genus **GRADUNGULA** gen. nov.

Cephalothorax low, with eight eyes in two rows, A.M.E. smallest. Chelicerae strong, directed forward, promargin with teeth, retromargin smooth. Maxillary lobes without serrula. Legs 4, 1, 2, 3, tarsal claws of legs 1 and 2 greatly modified; proclaw much longer

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Manuscript received September 7, 1954.

than retroclaw. Tarsi 1 and 2 flattened beneath and armed with numerous rod-like spines. Abdomen oval, spinnerets short.

Genotype *Gradungula sorenseni* sp. nov.

Gradungula sorenseni sp. nov.
Figs. 1, 2*a–c*

FEMALE

Measurements (in mm.):

Length of cephalothorax	4.68
Width of cephalothorax	4.04
Length of abdomen	8.28
Width of abdomen	5.23

	FEMUR	PATELLA	TIBIA	METATARSUS	TARSUS	TOTAL
Leg 1	3.53	1.29	2.94	2.58	1.28	11.62
Leg 2	3.23	1.34	3.04	2.78	1.14	11.53
Leg 3	3.03	1.34	2.13	2.77	1.04	10.31
Leg 4	3.94	1.48	3.59	3.78	1.43	14.22
Palp	2.04	0.74	1.19		1.69	5.66

Colour: Two longitudinal patches of deep yellow extend along the carapace and are separated by a median longitudinal dark brown band, which merges in front and behind with dark brown bands extending along the lateral margins. The ground colour of the abdomen is greyish brown with a median dark brown band extending down slightly more than half of the anterior dorsal surface, followed by an irregular transverse patch at three-quarters of its length. The dark brown areas are not formed by pigment but by closely spaced short black hairs. Chelicerae dark brown. Maxillae dark brown but anterior margins creamy white. Sternum dark brown with black shading on the median surface. Legs and palps banded with alternate dark and pale brown markings.

Carapace: The head region is narrower than the thoracic region, lateral margins subparallel, and relatively low but of the same height as the thoracic region. The lateral margins of the thoracic region are evenly rounded, widest between coxae 2 and 3 where the width is almost equal to the length of the carapace. A number of small setae are present on the clypeus and in the region of the eyes. A row of from 6 to 7 small setae extend back from the lateral eyes and a similar number extend back down the median line to the fovea. The fovea is longitudinal and deep and is surrounded by small setae. Faint traces of striae can be seen on the median surface of the carapace near the fovea.

Eyes: From in front the anterior row is slightly procurved and the posterior row recurved. From above the anterior row appears strongly procurved and the posterior row straight. The ratio of the eyes AME:ALE: PME:PLE = 2:5:4:4. The AME are separated from each other by a space equal to one half and from the ALE by twice of the diameter of an AME. The lateral eyes are sub-contiguous and are raised from the surface of the carapace by a small swelling. The distance between the PME, the PME and the AME, and the PME and the PLE is in all cases equal to twice the diameter of an AME. The median ocular quadrangle is wider behind than in front in the ratio of 11:7. The height of the clypeus is slightly more than three times the diameter of the AME. AME black, remainder pearly white.

Chelicerae: These are stout, directed forward, slightly divergent. Lateral condyles are absent. There is a series of closely spaced parallel ridges on the retrolateral surface of each chelicera which has the appearance of a typical stridulating structure. The fangs are strong and evenly curved. Promargin with a row of eight strong teeth, retromargin smooth but with a row of closely spaced long setae which form a scopula (Fig. 1*d*, *e*).

Maxillae: (Fig. 1*b*) These do not converge over the labium. The trochanter is inserted laterally and the basal portion of the maxilla is separated from the anterior portion by a distinct groove. The anterior margin is directed obliquely inwards and is provided with a dense scopula, but a serrula is lacking.

Labium: (Fig. 1*b*) Free. Wider than long in the proportions of 14:11. Lateral margins slightly curved, anterior margin indented and provided with ten setae.

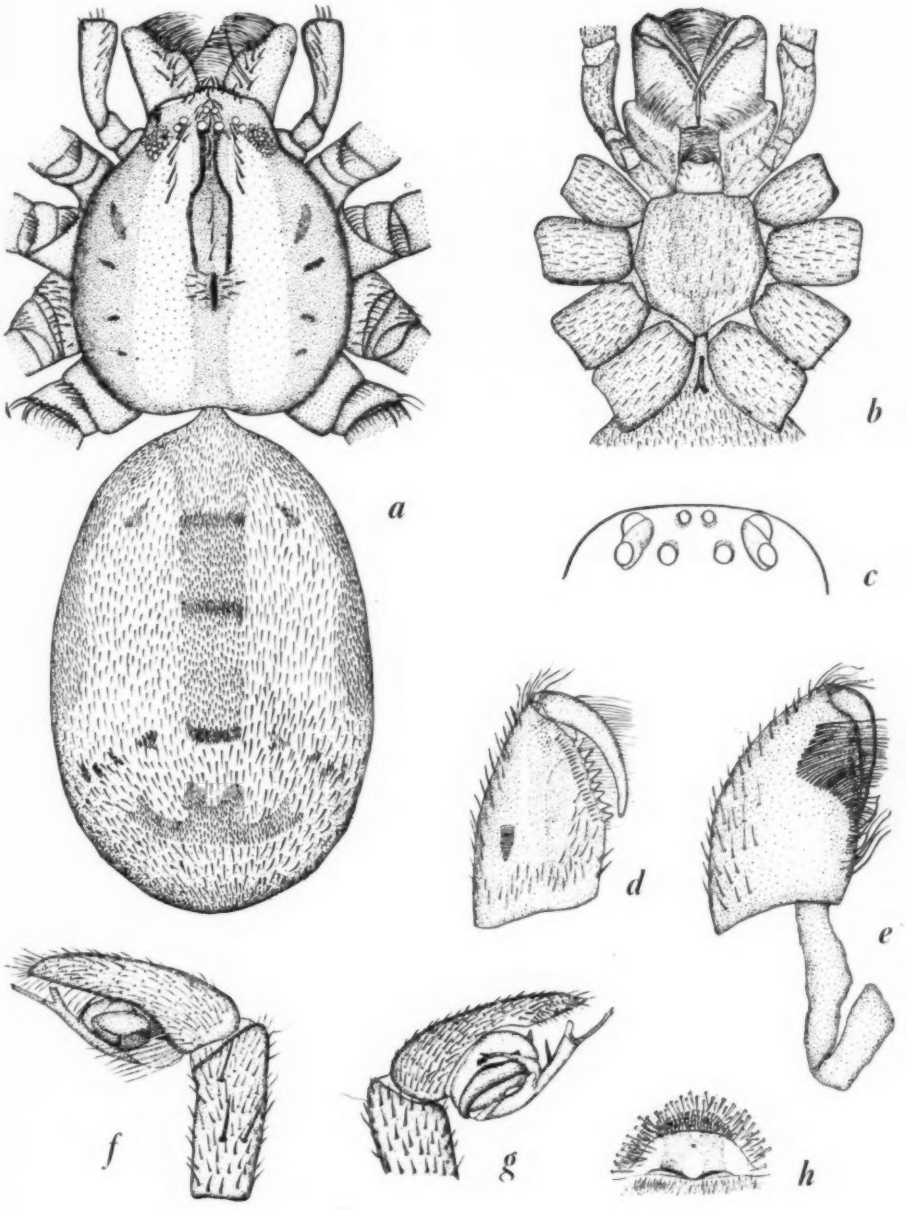

FIG. 1. *Gradungula sorenseni* sp. nov.: *a*, dorsal aspect of body of female; *b*, ventral aspect of anterior portion of body of female; *c*, eyes in dorsal view; *d*, retrolateral aspect of chelicera; *e*, prolateral aspect of chelicera; *f*, retrolateral aspect of male pedipalp; *g*, prolateral aspect of male pedipalp; *h*, epigynum of female.

Sternum: (Fig. 1*b*) Almost as wide as long, flattened, scutiform. The anterior margin is straight, lateral margins slightly rebordered, not extending laterally between the coxae. The posterior margin is broadly pointed and does not extend back between coxae 4, which are separated from each other by a distance equal to one fifth of their width.

Legs: 4.1.2.3. The superior claws of legs 1 and 2 are markedly dissimilar. The proclaw is extremely long and strongly developed, its length being equal to three-fifths of that of the tarsal segment and is smooth below except for six small teeth near the base. The reproclaw is equal to two-thirds of the length of the retroclaw and is normal in appearance, pectinate below with a row of eight to nine strong teeth (Fig. 2*b*). The inferior claw is slender and smooth, originating from a triangular plate below the superior claws. The tarsi of legs 1 and 2 are also modified. They are robust, convex dorsally but flattened beneath, with numerous rod-like spines arranged in rather irregular longitudinal rows on most of the ventral surface (Fig. 2*a*). The tarsus and claws of legs 3 and 4 are normal in structure, superior claws homogeneous, pectinate below with a row of from 10 to 11 teeth, inferior claw with a single tooth near the base.

Disposition of spines.—First leg; femur, dorsal 1p–1r–2–0–1r, prolateral 0–0-0–2–1d, elsewhere 0; patella 0; tibia, ventral 2–2–2, elsewhere 0; metatarsus, ventral 2–2–2–2; tarsus with numerous blunt spines on ventral surface as shown in Figure 2*a*. Second leg; femur, dorsal 1p–2–1r–1r–1r, prolateral 0–1d–1d–1d–1d, eslewhere 0; patella 0; tibia, ventral 1r–1r–1r, elsewhere 0; metatarsus, ventral 2–2–1p, elsewhere 0; tarsus as in leg 1. Third leg; femur, dorsal 2–1r–2–1r–2, prolateral 1d–0–1d–1d–1d, elsewhere 0; patella, prolateral 1, retrolateral 1, elsewhere 0; tibia, dorsal 1p–0–2–2, ventral 2–1p–2–2, prolateral 2–2–2–2, retrolateral 1d–1d–0–0; metatarsus, dorsal 2–2–2–2, ventral 2–2–2–2, prolateral 2–2–2–0, retrolateral 1d–1d–1d–2. Fourth leg; femur, dorsal 2–1p–2–1r–2, ventral 0, prolateral 1d–0–1d–1d–1d, retrolateral 0; patella, retrolateral 1, elsewhere 0; tibia, dorsal 1p–1p–1r–1r, ventral 2–0–1p–0, prolateral 2–2–2–0, retrolateral 1d–1d–1d–0; metatarsus, dorsal 2–2–2, ventral 2–2–2, prolateral 2–2–2, retrolateral 2–1d–1d; tarsus 0.

Trichobothria are present on the tibia of all legs and the metatarsus of legs 1 and 4. First leg, tibia with two distal, metatarsus with one distal. Second leg, tibia three, metatarsus none. Third leg, tibia three, metatarsus none. Fourth leg, tibia six, metatarsus, one distal.

Palps: Slightly longer than the tibia of leg 1. Closely clothed with both short and long smooth hairs. Spines.—Femur, dorsal 1–1–1; patella, dorsal 1–1–1; tibia, dorsal 1–0–1, ventral 0, prolateral 1–1–0, retrolateral 0–1–0. There is a row of five trichobothria on the dorsal surface of the tibia, increasing in size anteriorly. The tarsal claw is strong and is pectinate below with a single row of nine teeth.

Abdomen: Ovoid, entire surface covered with small serrate setae. The dark markings on the dorsal and lateral surfaces are formed by numerous small hairs which in these regions are darker in colour and more closely spaced. Two pairs of book lungs are present, posterior pair more closely spaced than anterior pair. The spiracles of the anterior pair open from the abdomen at about 0.57 of its length. The epigynum is lightly sclerotic and appears as shown in Figure 1*b*. There are six spinnerets, anterior and posterior pairs each of two segments, somewhat conical, and well separated at their bases. The median spinnerets are one-segmented and are closely spaced. A small colulus is present.

MALE

Measurements (in mm.):

Length of cephalothorax	4.58
Width of cephalothorax	4.09
Length of abdomen	5.57
Width of abdomen	3.08

	FEMUR	PATELLA	TIBIA	META-TARSUS	TARSUS	TOTAL
Leg 1....	4.23	1.64	3.44	3.53	1.43	14.27
Leg 2....	4.09	1.54	3.53	3.23	1.24	13.63
Leg 3....	3.79	1.38	3.03	3.54	1.23	12.97
Leg 4....	4.68	1.59	4.08	4.88	1.53	16.76
Palp.....	2.29	0.78	1.54		2.04	6.65

The male is very similar to the female in colouration and many structural features. Only the following characters need description.

Eyes: Ratio of AME:ALE:PME:PLE = 5:8:8:7. The AME are separated from each other by a distance equal to 0.6 and from the ALE by 1.6 of the diameter of the AME. The ALE and PLE are sub-contiguous and are placed on a low protuberance. The PME are separated from each other and from the AME by a space equal to 1.2 of the diameter of the AME. The PME are separated from the PLE by a space equal to 1.6 of the diameter of the AME. The median ocular quadrangle is wider behind than in front in the proportions of 11:7.

The chelicerae are as in the female and the series of ridges on the retrolateral surfaces.

Legs: The number and distribution of the trichobothria is as recorded for the female. The tarsal claws are also similar in structure. Disposition of spines.—First leg; femur, dorsal 0–0–2–2–2, elsewhere 0; patella 0; tibia, ventral 1r–1r–1r–0, prolateral 0–0–0–1d, elsewhere 0; metatarsus, ventral 2–2–2–2, elsewhere 0; tarsus as in female. Second leg; femur, dorsal 2–2–2–2–2, prolateral 1d–0–1d–0–0, elsewhere 0; patella 0; tibia, ventral 1p–2–2–2, elsewhere 0; metatarsus, ventral 2–2–2–2, elsewhere 0; tarsus similar to female but with a thick scopula on the retromargin. Third leg; femur, dorsal 2–2–2–2–2, prolateral 0–1d–1d–1d–1d, elsewhere 0; patella, retrolateral 1, elsewhere 0; tibia, dorsal 2–1p–2–2, ventral 1d–0–1d–0, prolateral 1d–1d–1d–1d, retrolateral 1d–0–1d–0; metatarsus, dorsal 1p–2–1r–2, ventral 2–2–2–0, prolateral 1d–1d–1d–2, retrolateral 2–0–2–1d; tarsus 0. Fourth leg; femur, dorsal 2–1r–2–2–2, prolateral 1d–2–1d–1d–1d, elsewhere 0; patella, prolateral 1, retrolateral 1, elsewhere 0; tibia, dorsal 2–2–2–2, ventral 2–1p–2–0, prolateral 1m–1m–1m–0, retrolateral 1d–0–1d–1d; metatarsus, dorsal 2–2–2–2, ventral 2–2–2–2, prolateral 2–1d–2–2, retrolateral 2–1d–1d–2; tarsus 0.

Palps: (Fig. 1*f*, *g*) There are five trichobothria in a single row along the dorsal surface of the tibia. The tarsal segment is slightly longer than the tibia. The genital bulb is relatively simple. Near the anterior margin a strong lateral branch curves back over the surface of the bulb, and terminates in a sharp curved tooth which rests against a hooked process rising from the prolateral surface. There is also a small tooth on the anterior surface of the lateral branch at about one half of its length. A further more slender branch is directed inward toward the tarsus immediately beyond the bulb. The embolus then widens to a point halfway between the anterior surface of the bulb and the tip of the tarsal segment. The alveolus is oval in outline and is situated on the middle of the ventral surface. There is a fringe of long hairs along the retromargin of the alveolus which extends over the surface of the bulb.

TYPES: *Holotype*, female, Franz Josef, Westland, from under log, 30 April, 1951, R. R. Forster (C.M.A. 1042); *allotype*, male, same data (C.M.A. 1043); *paratypes*—one female, same data as holotype (C.M.A. 1044); Fox Glacier, Westland, September, 1951, M. Warren, two females (C.M.A. 1045); Halfmoon Bay, Stewart Island, January, 1952, O. Allan, two immature females (C.M.A. 1049); Orepuki, west side of Longwood Range, September, 1948, J. H. Sorensen, one immature female (C.M.A. 1055); Stillwater Base Camp, Caswell Sound, March 13, 1949, R. K. Dell, two males, one immature (D.M. 2/1014); Leslie Clearing Track, Caswell Sound, March 16, 1949, R. K. Dell, one male, one female (D.M. 2/1015); Okarito, Westland, December 7, 1949, R. R. Forster, one male (C.M.A. 1048); same locality, April 26, 1951, R. R.

Forster, one immature female (C.M.A. 1051); Moana, Westland, March 10, 1950, R. R. Forster, two males, one immature (C.M.A. 1047); Kiwi Valley, Lewis Pass, November 14, 1949, R. R. Forster, one immature female (C.M.A. 1046); Lake Taylor, Canterbury, April 14, 1952, R. R. Forster, one female (C.M.A. 1054); Woodpecker Bay, Westland, January 22, 1950, R. R. Forster, one immature female (C.M.A. 1052); South Terrace, Karamea, January 21, 1950, R. R. Forster, three immature males, one immature female (C.M.A. 1053); Oparara, Karamea, January 24, 1950, R. R. Forster, one immature male, three immature females (C.M.A. 1050). Paratype specimens are also located in collections of The American Museum of Natural History, New York, Professor B. J. Marples, University of Otago and Professor V. V. Hickman, University of Tasmania.

Gradungula woodwardi sp. nov.
Fig. 2*d–g*

Although the material on which this species is based consists of only three immature specimens, two of which are probably less than half grown, the characters discussed below clearly separate this species from *G. sorenseni*. It would be of considerable interest to have adult material available for description in view of the close relationship of this species to the New Zealand form.

FEMALE (Immature specimen, probably two moults from maturity)

Measurements (in mm.):

Length of cephalothorax	2.36
Width of cephalothorax	1.76
Length of abdomen	2.91
Width of abdomen	1.98

	FEMUR	PATELLA	TIBIA	METATARSUS	TARSUS	TOTAL
Leg 1	1.92	0.74	1.48	1.18	0.89	6.21
Leg 2	1.98	0.60	1.46	1.04	0.88	5.96
Leg 3	1.62	0.73	1.18	1.31	0.59	5.43
Leg 4	2.09	0.75	1.63	1.76	0.81	7.04
Palp	0.86	0.43	0.66		0.82	2.77

The colour pattern of the cephalothorax is similar to that of *sorenseni*, but the abdomen is uniform greyish-brown and lacks the median black patches. The legs are provided with alternate dark and pale brown bands.

The structure of the sternum, labium, and maxillary lobes are as in *sorenseni*. The chelicerae are also similar in structure although the teeth on the promargins appear to be relatively smaller.

Eyes: The ratio of the AME:ALE:PME:PLE = 5:9:6:6. The AME are separated from each other by 0.4 of their diameter and from the ALE by 1.2 of this distance. The lateral eyes are contiguous and are placed on a common, low tubercle. The PLE are separated from the PME by 1.2 of the diameter of the AME. The PME are separated from each other by 1.6 and from the AME by 0.6 of the diameter of the AME. The median ocular quadrangle is wider behind than in front in the ratio of 10:6. The posterior width is also greater than the length of the quadrangle in the ratio of 10:7.

Legs: Spines are distributed as follows.—First leg; femur, dorsal 1.1.1.0.0, prolateral 0.0.0.1.1, elsewhere 0; patella 0; tibia, ventral 2.2, elsewhere 0; metatarsus, dorsal 0, ventral 0.0.0.2, prolateral 1.1.1.1, retrolateral 1.1.1.1. Second leg; femur, dorsal 1.1.1.0.0, prolateral 0.0.1.1.1, elsewhere 0; patella 0; tibia, ventral 1p.1p.1p, elsewhere 0; metatarsus, ventral 1.1.1.2, prolateral 0.0.0.1. Third leg; femur dorsal 1.1.1.1.1, ventral 0, prolateral 0.1d.1d.1d.1d, retrolateral 1d.1d.1d.1d.1d; patella, prolateral 1, retrolateral 1, elsewhere 0; tibia, dorsal 0.1.1.0, ventral 2.2.2.0, prolateral 1.1.1.1v, retrolateral 1.1.1.1v; metatarsus, dorsal 0.0.1.1, ventral 1.1.1.1, prolateral 2.0.2.1, retrolateral 2.0.2.1. Fourth leg; femur, dorsal 1.0.1.0.1, ventral 0, prolateral 1d.0.0.1d.1d, retrolateral 0.0.0.0.1d; patella, prolateral 1, ventral 1; tibia dorsal 1.1.1.0.1, ventral 0.2.0.2.2, prolateral 1d.0.1d.0.1, retrolateral 1d.0.0.0.1; metatarsus, dorsal 1.0.0.0.2, ventral 2.2.0.2, prolateral 0.10.1.0, retrolateral 0.0.1.0.1.

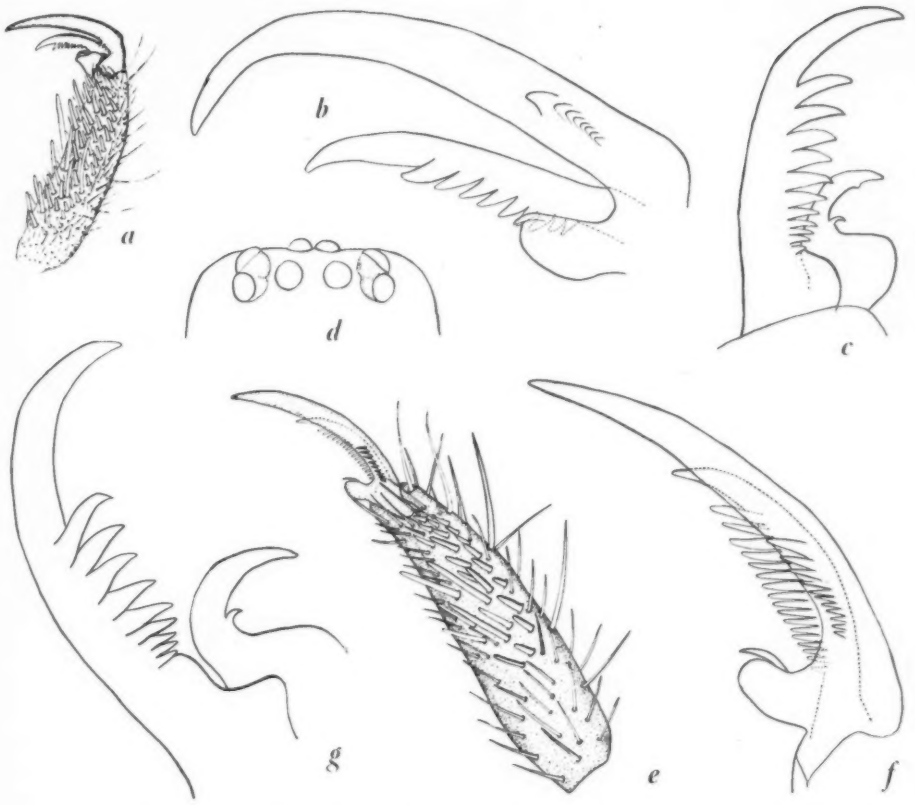

FIG. 2. Structural details of species of *Gradungula*. *a–c*, *Gradungula sorenseni* sp. nov.: *a*, tarsus and claws of first leg of female; *b*, tarsal claws of first leg of female; *c*, tarsal claws of fourth leg of female, showing one superior claw. *d–g*, *Gradungula woodwardi* sp. nov.: *d*, eyes in dorsal view; *e*, tarsus and claws of first leg; *f*, tarsal claws of first leg; *g*, tarsal claws of fourth leg, showing one superior claw.

Trichobothria are distributed as follows.—First leg; tibia, 1.2.1.2; metatarsus, 1 distal. Second leg; tibia 1.2.1.2; metatarsus, 1 distal. Third and fourth legs with 6 pairs on tibia and 1 distal on metatarsus.

The spines on the ventral surface of tarsi 1 and 2 are not as numerous as in *sorenseni* and are practically limited to the distal half of the segment. The tarsal claws of legs 1 and 2 are modified as in *sorenseni* but the teeth on the ventral surface of the two superior claws are more numerous. There are from 11 to 12 on the proclaw and 17 to 18 on the retroclaw (Fig. 2*f*). The superior claws of legs 3 and 4 are homogeneous, with nine strong teeth (Fig. 2*g*).

Palp: As in *sorenseni* but with four trichobothria on the dorsal surface of the tibia.

TYPES: *Holotype*, female (immature), Mount Hobwee, Lamington Plateau, South Queensland, from leaf mould gathered in rain forest, 27 September, 1953, T. E. Woodward; *Paratypes*—Mount Merino, Lamington Plateau,

from moss and lichens, 27 September, T. E. Woodward, one immature female; Binna Burra, Lamington Plateau, from leaf mould gathered in rain forest, 28 September, T. E. Woodward, one immature female. The specimens are at present housed in the Canterbury Museum.

The description given above will need considerable amplification when mature specimens are available for examination but the structure of the tarsal claws is sufficient to separate this species from *sorenseni* as this has been found to be constant throughout the range of specimens of the latter species which have been examined, both adult and immature. The occurrence of these two closely related species, separated by over a 1,000 miles of open sea, is of great interest and adds yet another example to the already lengthy list showing the close affinity of the New Zealand fauna with a section of the Australian fauna. If, as many geologists believe, the last possible land link between these two areas was in the late Mesozoic, the rate of speciation for many groups must be extremely slow.

NOTES ON THE BIOLOGY OF *Gradungula sorenseni*

These spiders are to be found in the forested areas of the west coast of the South Island of New Zealand and also on Stewart Island. In all these areas the rainfall is high and the forest is wet continuously. It would appear that the Australian species, also, is limited in distribution to similar forest conditions.

The spiders are nocturnal, and are found during the daylight hours sheltering beneath logs or small pieces of bark and twigs on the forest floor. At such times they are usually sluggish and the legs are held close to the body. While thus quiescent the abdomen is usually covered with a number of small droplets of water which cling to the hairs. Field observations supported by laboratory experiments would indicate that the species is extremely susceptible to dryness and requires a high relative humidity for survival.

It is noteworthy that no sign of any silken web, or in fact any silken structure at all, has been found associated with the spiders in the field. Observations carried on over a period of six months under laboratory conditions with both males and females have shown only the occasional use of a drag line. Food in the nature of flies and other small insects was readily accepted and was captured by hunting, although the distance from which the prey was observed was short, rarely more than 5 or 6 inches. The use of the claws of the first two pairs of legs in the capture of prey was only observed in one instance when the superior claws were flexed against the tarsal segment to hold a harvestman (*Nuncia* sp.), but it was released without being killed.

No mating behavior has been observed and the appearance and structure of the egg-sacs and sperm web are unknown.

NOTES ON THE INTERNAL ANATOMY OF *Gradungula sorenseni*

Digestive System: The thoracenteron is of the "classic" type, with four pairs of unbranched diverticulae extending laterally and downwards into the coxae of the four pairs of legs. There are from 12 to 14 large multicellular pyriform glands within each maxilla which open from a circular sieve plate on the inner margin near the base.

Excretory System: A pair of biramous Malpighian tubes open into the gut anterior to the stercoral pouch. The coxal glands are well developed. There is a single outlet for each gland situated at the base of the coxae of the first pair of legs. The labyrinth runs back from a terminal saccule as a straight tube, into which a small accessary saccule opens at about the level of the third pair of legs. The labyrinth then distends above coxa 4 before turning down to run back to the opening on the coxae of the first pair of legs. Dorsal and ventral "dips" are present on this latter portion in the region of coxae 3 and 4.

Poison Glands: These are endocephalic. They are cylindrical and are bent down in the region of the second pair of coxae to run forward for a short distance before terminating bluntly.

Silk Glands: In the female only cylindrical and pyriform glands appear to be present. A large number of long cylindrical glands extend back above and lateral to the gut and appear to open from both the median and posterior spinnerets. Numerous small pyriform glands and a group of three large pyriform glands open from each anterior spinneret. In the male all spinnerets appear to be supplied from small pyriform glands while a small bunch of much convuluted cylindrical glands opens from each anterior spinneret.

Respiratory System: Two pairs of lung books are present. The anterior pair occupies the normal position and has from 50 to 54 lamellae. The posterior pair are smaller and more closely spaced and each is composed of from 21 to 22 lamellae.

Circulatory System: The heart is large and is supplied with four pairs of ostia.

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Submarine Topography South of Hawaii[1]

K. O. EMERY[2]

GEOMORPHIC AND STRUCTURAL evidence strongly suggests that the center of volcanism in the Hawaiian Islands has migrated slowly from northwest to southeast. This movement is reflected in a progression from the eroded and reef-covered volcanic platform of Midway Island to the periodically active volcanoes of Kilauea and Mauna Loa on the island of Hawaii. From the general age relationships of the islands it might be supposed that a still younger center of volcanism may now be building one or more new cones on the sea floor southeast of Hawaii, eventually to form new islands at that end of the chain.

Soundings shown on charts of the area south and southeast of Hawaii prior to 1954 were taken mostly by various ships that happened to be passing through the area. They are too sparse and poorly positioned to reveal many details of the topography; however, several single isolated soundings on U. S. Coast and Geodetic Survey Chart No. 4179 suggested the presence of as many separate submarine mountains. At the request of the Office of Naval Research the Commander Service Forces Pacific made available a ship for a brief bathymetric survey of these areas. This ship was U.S.S. Patapsco, AOG 1, a 16,000 barrel 10-knot oil tanker that carried a NMC-2 echo-sounder. The great stability of the ship permitted routine sounding operations to be carried on in spite of the fact that most of the sounding traverses paralleled the trough of waves produced by winds of up to Force 6.

Appreciation is due Lt. J. W. Downing, commanding officer, and Lt. j.g. C. J. Kelly, navigator, for their cooperation and interest in the work. The Hawaiian names for the five seamounts were kindly supplied by Mrs. Mary K. Pukui and Mrs. Martha Hohu of the Bernice P. Bishop Museum in Honolulu and by Dr. Gordon A. Macdonald, director of Hawaiian volcano observatory. Dr. Macdonald kindly read the manuscript, suggesting several improvements. The study was made possible by funds provided by Office of Naval Research contract Nonr 228 (06).

METHOD

Between 0100 June 29 and 1000 July 2, 1954 about 800 miles of sounding traverses were run in the area of Figure 1. Soundings were read visually at one-minute intervals by crew-members but only alternate soundings were plotted on the base chart for Figure 1. Index error and motor speed error were constant within the accuracy of their measurement. Accurate positions were obtained within 4 miles of shore by visual pelorus bearings. Radar fixes to 15 miles from shore proved less reliable. Only star fixes could be used farther off-shore because the area is one of base line extension for Loran. Accordingly, the survey was set up in such a way that sounding in the nearshore areas was done during the daytime, and the long radial traverses were started from a land fix at dusk and ended with a landfall after dawn. Errors in the dead-reckoning positions at the ends of traverses were pro-rated over the entire traverses, taking into account

[1] Allan Hancock Foundation contribution No. 156. University of Hawaii Marine Laboratory contribution No. 72. Manuscript received January 12, 1955.

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ship speed and offsetting of the course by the wind and sea.

About 2,430 two-minute interval soundings resulted from the survey. These soundings were plotted on U. S. Coast and Geodetic Survey Chart No. 4115 (1951 edition) which also contains 380 soundings in the area of interest. An additional 220 useful soundings were transferred to the plotting chart from a compilation made by Dietz and Menard (1953) for their general map of the Hawaiian region. A few additional old soundings were omitted because they differed markedly from others in the vicinity and were considered erroneous in position. The total of 3,030 soundings served as the basis for the sea floor contour lines of Figure 1.

Corrections for true sound velocity in the water were made using data from the Marshall Islands (Emery, Tracey, and Ladd, 1954) so that the contour lines would indicate actual depths. Contour lines of land topography at the same interval of 1,500 feet (250 fathoms) were added to the chart from the geological map of Hawaii (Stearns and Macdonald, 1946).

RESULTS

The survey shows the presence of three main physiographic units: lower slopes of Hawaii, Hawaiian Deep, and Hawaiian Arch (Figures 1 and 2). Superimposed on these units are five seamounts.

Lower Slope of Hawaii

The lower slope of the island of Hawaii extends a distance of between 10 and 20 miles from shore to a depth of more than 15,000 feet. Instead of being a simple smooth surface the slope has been made somewhat irregular by four kinds of secondary features. One such feature is volcanic cones, two of which are located directly south of Kilauea. These cones will be discussed in the section on seamounts. A second irregularity is that of elongate ridges that extend seaward off both South Cape and Cape Kumukahi. Both ridges are probably the result of vulcanism along rifts or zones of weakness, extensions of which have been recognized on land (Stearns and Macdonald, 1946, p. 25) and are exemplified by a row of many small craters between Cape Kumukahi and Kilauea Crater. As would be expected of volcanic activity, at least one hill rises above the general level of the outer end of the ridge off Cape Kumukahi. A second hill is shown on U. S. Coast and Geodetic Survey Chart No. 4115 to rise from depths of more than 1,800 feet to within 210 feet of the sea surface (35 fathoms—Existence Doubtful) at a point 5 miles off Cape Kumukahi, but detailed sounding traverses made in this area failed to reveal depths shallower than 1,800 feet. The ridges bear a striking resemblance to similar features of guyots in the Marshall Islands, particularly Sylvania Guyot near Bikini Atoll (Emery, Tracy, and Ladd, 1954).

The third kind of irregularity of the slope is a greater than usual steepness near the shore from south of Kilauea Crater northeastward to near Cape Kumukahi; this steepness is believed to result from the presence of a normal fault that is parallel to shore and is *en echelon* with faults of the Hilina zone on land. The latter is marked by two scarps 1,000 to 1,500 feet high and the scarp on the sea floor is nearly as high. The fourth and last kind of irregularity on the slope is a long broad low ridge that extends eastward from the northernmost parasitic cone. This area is one in which 4,553 earthquakes were detected in a six-week period of 1952 (Macdonald, 1952). Whether this low ridge is of volcanic or structural origin is unknown. The submarine slope appears to be free of a fifth kind of secondary land form, submerged wave-formed terraces, unlike the northeastern coast where Dietz and Menard (1953) reported an extensive terrace at a depth of 1,080 feet.

The steepness of the lower slopes was measured along 11 of the sounding traverses, using for each measurement the gradient of the steepest 6,000-foot depth zone and avoiding as much as possible the influence of sec-

ondary features. The mean of these values is 11°. In comparison, the maximum, mean, and minimum slopes of 6,000-foot height zones of the subaerial part of Mauna Loa were found to be 11°, 7°, and 3°, respectively. It is evident from these measurements as well as from inspection of the contour lines of Figure 1 and of the profiles of Figure 3 that the submarine slopes of this part of Hawaii are steeper than the subaerial slopes.

Hawaiian Deep and Arch

Beyond the foot of the lower slope of Hawaii is a broad depression that extends along most of the northeastern side of the entire chain and along part of the southwestern side, as mentioned by Stocks (1950) and described more fully by Dietz and Menard (1953). The 18,000-foot contour of Figure 1 shows the deepest part of the Hawaiian Deep; farther southwest the axis of the Deep shallows to 17,200 feet and its course is uncertain west of 155° 10′ W. owing to its low relief and the low density of soundings.

South and east of the axis of the Deep the bottom gradually becomes shallower until at the end of each long radial sounding traverse the depths are about 1,000 feet shallower than where the traverse crosses the Hawaiian Deep. This gentle northwestward-facing slope marks the inner side of the Hawaiian Arch, a 200-mile wide bulge that borders the Hawaiian Deep. The scarp that Dietz, Menard, and Hamilton (1954) found to border the outer edge of the Hawaiian Arch was not reached in this survey. In only a few places do the sounding traverses in the Hawaiian Deep and Arch have local depth variations that exceed 100 feet, the probable limit of accuracy of reading the echo-sounder; accordingly, it is supposed that the bottom is mantled by a thick layer of sediment.

The Hawaiian Deep is attributed by Dietz and Menard (1953) to crustal depression caused by the great load of the volcanic pile that comprises the Hawaiian Islands. The adjacent Hawaiian Arch they believed to be a related elastic bulge.

Seamounts

Five separate topographic highs were investigated during the survey. For convenience all will be called seamounts though three of them approach the lower limit of size and isolation required for application of the term, seamount, by the International Committee on Nomenclature of Ocean Bottom Features (1953).

Four of the seamounts were indicated by single soundings on previous charts (Table 1); however, the survey located new shallowest soundings as much as 4,100 feet shallower than the original ones (Table 1). One small deep seamount (*Hohonu*—"deep as a pit or

TABLE 1
CHARACTERISTICS OF THE FIVE SEAMOUNTS

	Present Survey—Corrected Feet	Previous Chart—Uncorrected Fathoms	Previous Chart—Corrected Feet	Height above Surroundings—Feet	Diameter of Base—Statute Miles	Mean Steepness of Slopes—Degrees
Papa'u	2490	450	2910	3000	6	9?
Loihi	3222	783	4932	9000	14	17
Wini	5346	990	6198	12000	20	16
'Apu'upu'u	5832	1600	9924	10500	21	18
Hohonu	11478	....	....	5500	6	20

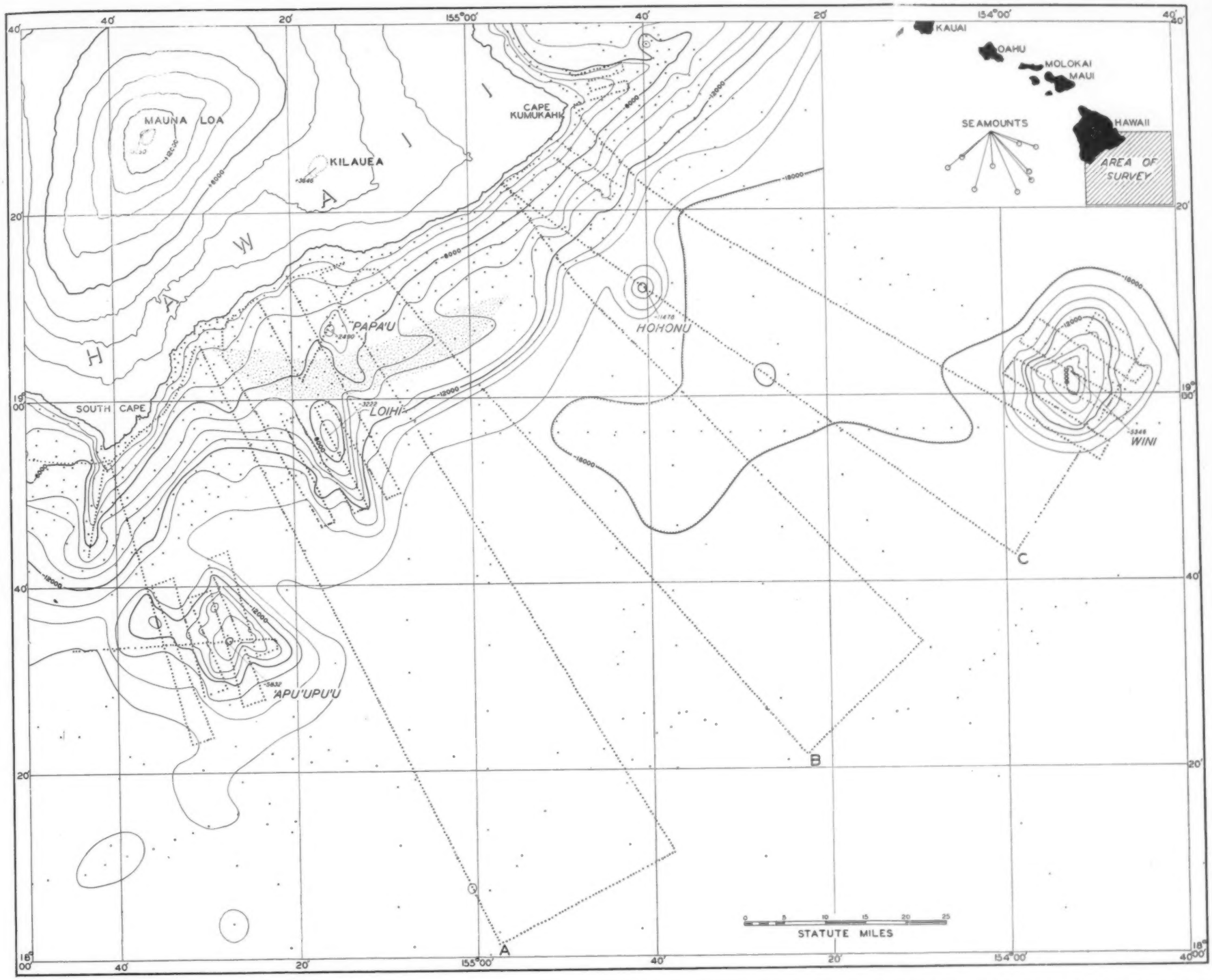
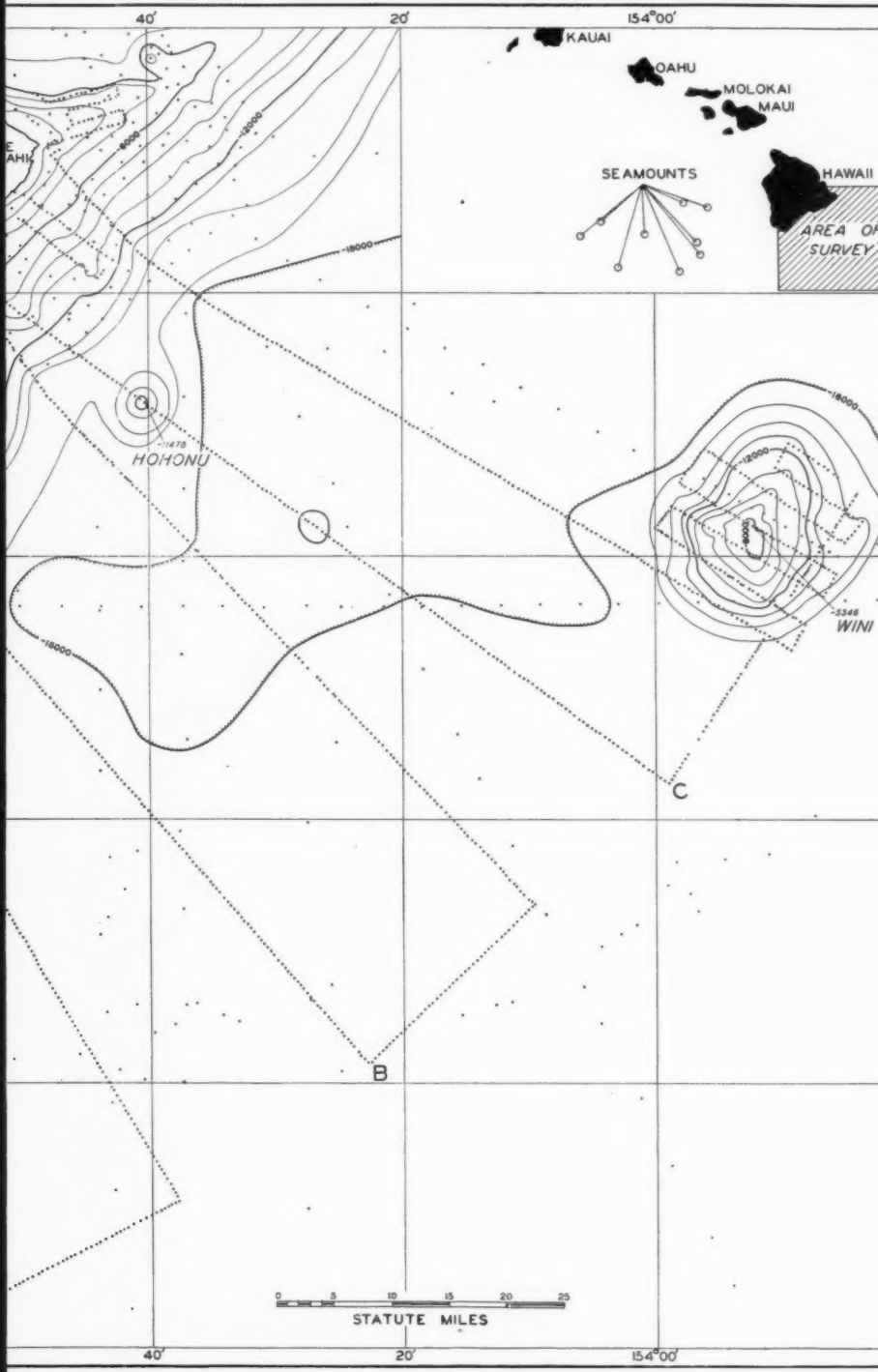


FIG. 1. Map showing topography of southern portion of Hawaii and vicinity. Submarine topography based principally on the survey of June 29 to July 2, 1954, made by the U.S.S. "Patapsco." Contour interval—1,500 feet (250 fathoms); large dots indicate soundings (those closely spaced were taken by the "Patapsco," the widely scattered ones from other sources); finely dotted portion is the area of seismic activity in 1952.



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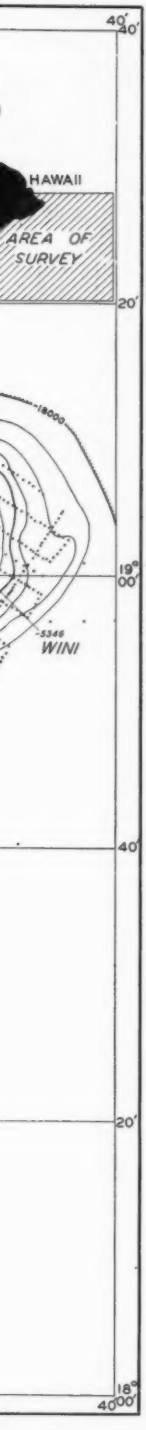

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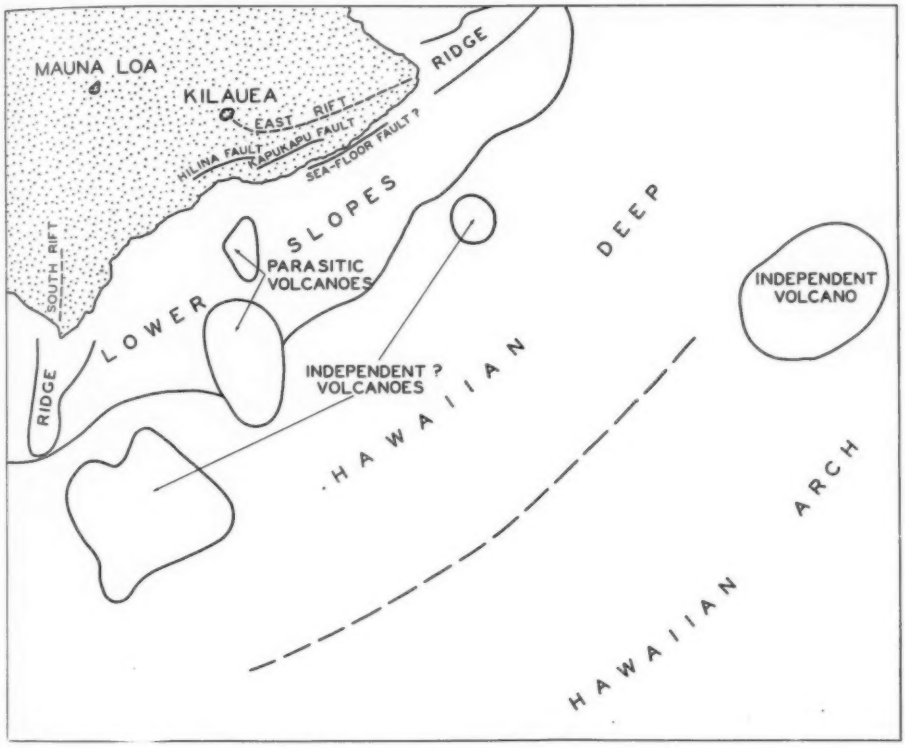

FIG. 2. Physiographic interpretation of Figure 1.

well, the deep sea") was not previously known.

The mean basal diameters of the seamounts range from 6 to 21 miles, so that two of them are intermediate in diameter between the subaerial part of Lanai Island (13 miles) and Kauai Island (27 miles). The seamounts rise 3,000 to 12,000 feet above their surroundings, a relief that is about three times that of the subaerial portions of the various islands in the Hawaiian Chain when expressed as ratio of relief to diameter. The greater relief is, of course, also indicated by steeper slope: a mean of 17° for the seamounts as compared to 11° for the submarine slope of Hawaii and 7° for the subaerial slope of Mauna Loa (Table 1 and Fig. 3). If slope corrections had been applied to the soundings, the submarine slopes would have been slightly steeper.

One of the seamounts (*Wini*—"coming to a point, sharp pointed") is conical in shape, one (*Loihi*—"to extend, to be long") is elongate, one (*'Apu'upu'u*—"a rough, uneven surface, such as a hillock") is irregular with several peaks, and the other two smaller ones (Hohonu and *Papa'u*—"to be shallow, as water") are of uncertain shape, possibly conical. Small irregularities suggestive of craters are present at the tops of three (Wini, 'Apu-'upu'u, and Hohonu), though it is obvious that the existence of small craters cannot be proven without much more detailed surveys than this one. None of the seamounts has a flat top like guyots but then most of the seamounts are deeper than most guyots and they probably also are younger.

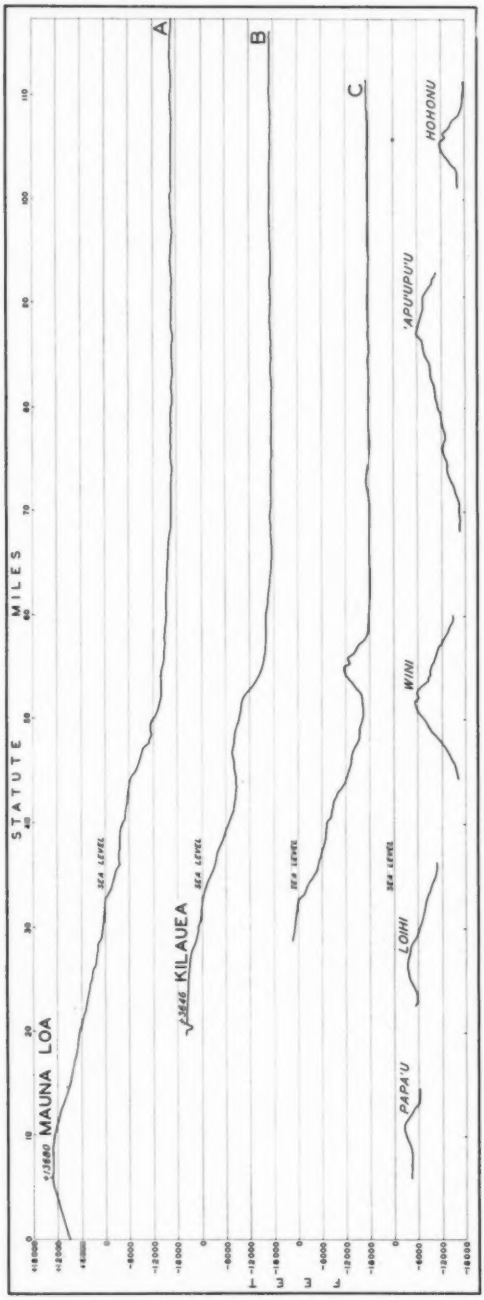

FIG. 3. Profiles of three sounding traverses (A, B, and C) of Figure 1 and of the five seamounts. Vertical exaggeration = 2.0. The slope from the top of Mauna Loa to the bottom of the Hawaiian Deep is the highest continuous slope in the world, approximately 32,000 feet.

None of the seamounts is seismically active within the limitations of the seismograph net on Hawaii. The 1952 belt of active seismicity south of Hawaii appears to pass between the two shallowest seamounts (Papa'u and Loihi) (Fig. 1), but conceivably some of the recorded seismic activity may still be related to them.

In summary the seamounts differ from the known Hawaiian volcanoes in some respects: higher relief (relative to diameter), steeper slopes, and lack of seismic activity. In spite of these differences the general shapes of the features and the geological and geographical environment is such that there is a high degree of probability that the seamounts are of volcanic origin, and correspondingly that the differences which exist may be indications of the nature of the early stages of a volcano forming well below sea level. If this conclusion is correct then the two shallowest seamounts (Papa'u and Loihi) must be considered parasitic (in the sense of topography—not activity) volcanoes on the flank of Kilauea-Mauna Loa, two ('Apu'upu'u and Hohonu) are probably independent volcanoes located at the foot of the slope, and one (Wini) is certainly an independent volcano, being located on the opposite side of the Hawaiian Arch from Hawaii (Fig. 2). If they are volcanoes. their age may be Late Tertiary to Pleistocene in accordance with the youth of the rest of the Hawaiian Chain. Quite probably they are even younger than the rest of the islands as suggested by the general movement of the center of volcanic activity from northwest to southeast (Stearns, 1946). It is impossible to state definitely, however, that the seamounts do constitute such an extension, but such is more likely than that they are unrelated and isolated volcanoes like the ones scattered about the area west of Hawaii (insert map of Fig. 1).

CONCLUSIONS

The relationship of Mauna Loa and Kilauea to the lower slope of Hawaii and its parasitic cones, ridges, fault scarp, and belt of seismic activity, to the Hawaiian Deep and Arch and to superimposed seamounts is such that it is exceedingly desirable to obtain more information on the submarine topography and bottom materials of the region. This is even more important in a geophysical sense when one considers that the submarine area of the chain far exceeds the subaerial area and that the effort expended on the land area to date is almost infinitely greater than that devoted to study of the submarine area.

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Reproduction and Affinities of *Dasyptilon* (Ceramiaceae; Rhodophyceae)[1]

DAVID ERSKINE[2]

THE GENUS *Dasyptilon* was set up by Feldmann-Mazoyer in 1950, for the New Zealand species long known as *Plumariopsis pellucida* (Harv.) de Toni. (Although doubts as to its identity with Harvey's type had been raised both by the New Zealanders and by G. Feldmann herself, the type of *Ptilota pellucida* Harv. seems conspecific, permitting ascription of the correct name *D. pellucidum* to (Harv.) de Toni, rather than "(Laing) de Toni.") She indicated as distinctive two important vegetative characteristics, the obliquely-dividing apical cell, and the rhizoidal cortication, and in addition the position of the tetrasporangia. However, the development of the cystocarp was quite unknown. Opportunity and incentive for its investigation was furnished by the collection of abundant female material in March, 1949, at St. Clair, Otago, South Island, New Zealand, by G. F. Papenfuss.

The vegetative structure of the purplish feathery fronds is essentially that of the Ptiloteae. The apical cell divides obliquely and alternately to left and right. Each cell of the filament which results produces two branches, the first from the longer side, one or two cells behind the apex (Fig. 2*b*); the second on the shorter side, one or two cells further back. In the vegetative shoot, the first branch becomes secondarily branched, the second remains simple, thus building up a distichous frond of alternating long and short branches.

In the fertile shoot, each short branch bears a four celled carpogonial branch upon its proximal cell. This cell is, in respect to the main axis, pericentral, as is typical of ceramiaceous procarps. Apparently the carpogonial branch is produced before the sterile cell (rudimentary vegetative short branch) (Figs. 1*a*, 2*b*), a development which may be characteristic of the Ptiloteae, as it has been noted both by Kylin (1923) in *Ptilota*[3] *plumosa* (Huds.) C. Ag. and by Suneson (1938) in *Plumaria*[3] *elegans* (Bonnem.) Schmitz, though Drew (1939) found that in the latter either might be produced first. If no carpogonium of the shoot is fertilized, the short branches resume growth to their normal character (Fig. 1*a*). In event of fertilization, further growth of the shoot above the fertile axial cell is checked by diversion of its nutriment to the gonimoblast. The primordial long branches, one to three cells in length, produce a terminal hair and cease growth (Fig. 2*a*, *d*). Apical development ceases in the short branches when they are composed of only the pericentral and (sometimes) a terminal sterile cell. The whole apex of the shoot may be deflected laterally by the growth of the cystocarp and becomes overtopped by several vigorous involucral branches arising from the axial cell below the fertile one. Occasionally

[1] This study was carried out in the Department of Botany at the University of California, Berkeley. Manuscript received February 12, 1954.

[2] Department of Geography, University of Toronto.

[3] Generic names proposed for conservation.

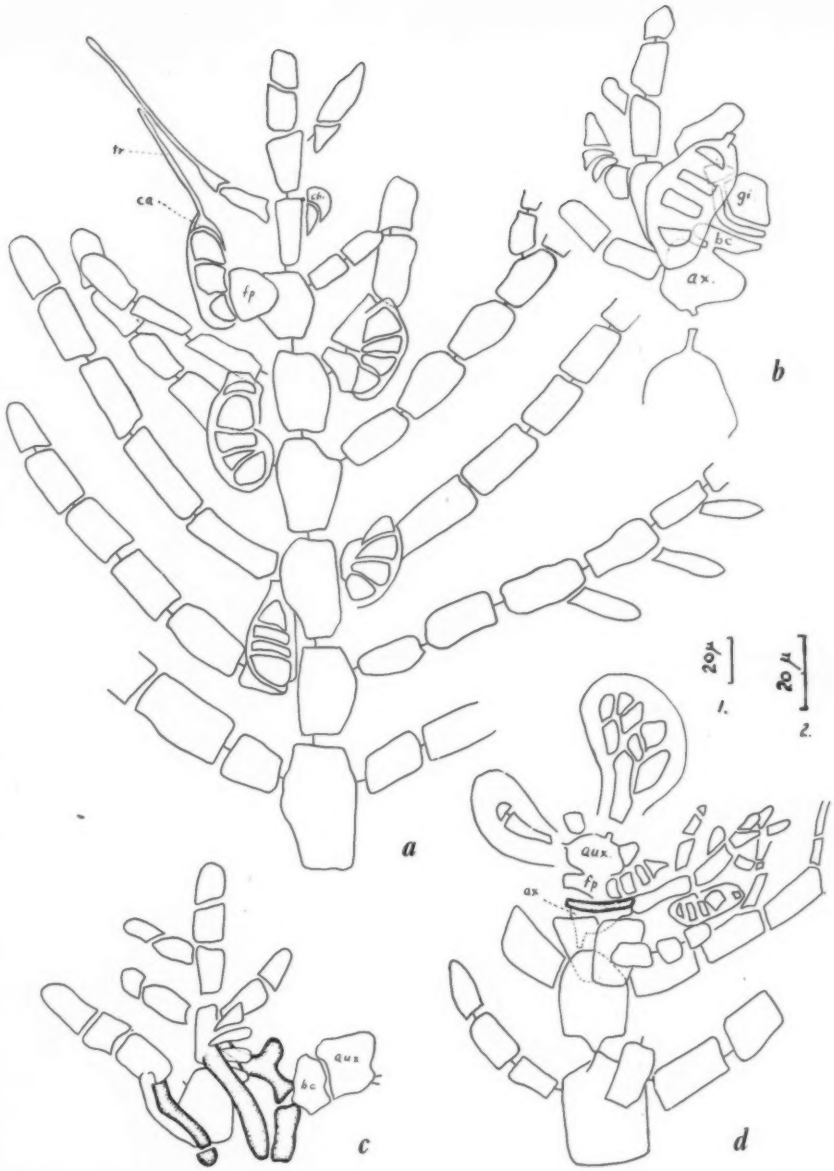

FIG. 1. *Dasyptilon pellucidum* (Harvey) Feldmann-Mazoyer. *a*, A female shoot which did not become fertilized, showing development of the short branches beyond the procarps (Scale 2); *b*, cystocarp, at first division of auxiliary cell (Scale 2); *c*, base of cystocarp, showing development of rhizoids (Scale 2); *d*, apex of fertile shoot deflected to one side by development of cystocarp (Scale 1). *ax.*, axial cell (fertile); *aux.*, auxiliary cell; *bc.*, basal cell (of Oltmanns); *ca.*, carpogonium; *cbi.*, carpogonial branch initial; *fp.*, fertile pericentral cell; *gi.*, gonimolobe initial; *tr.*, trichogyne. The rhizoids are shaded.

the axial cell second below the fertile one also produces involucral branches (Fig. 1*d*). These all have the structure of axial filaments, though one commonly surpasses the rest.

Post-fertilization stages follow a course typical for the Ptiloteae. The trichogyne is separated from the carpogonium by a septum and then collapses. The auxiliary cell is produced from the adaxial side of the fertile pericentral cell, of which a small portion remains as a "basal cell," to use Oltmanns' terminology (Fig. 1*d*). In these stages a cell is intercalated between the carpogonium and the third cell of the auxiliary branch. This suggests that it is here that carpogonium and auxiliary cell fuse by mediation of a connecting cell produced by the former (Fig. 1*d*, 2*a*). From the auxiliary cell three or four gonimoblast initials are produced, at least the first two developing into gonimolobes (Fig. 2*c*). The basal cell of each gonimolobe cuts off carpospores but remains distinct as a long stalk cell, like a paler handle to the cluster of heavily pigmented spores. Such stalk cells are characteristic of the Crouanieae, the Carpoblepharideae and at least *Plumaria elegans* among the Ptiloteae, but are not found among the presumably derived Ceramieae.

At the same time that growth of the apex is arrested, a rhizoid grows down from each side of the axial cell above the fertile one, and another from the proximal cell of the long branch attached to the fertile axial cell (Fig. 2*a*). These rhizoids may become two- or even four-celled, and extend around the base of the cystocarp like the ribs of a skeleton (Fig. 1*c*, 2*a*). Feldmann-Mazoyer (1940) illustrated such rhizoids in *Seirospora Giraudyi* of the Callithamnieae. They seem a constant feature of the rhizoidally corticated Callithamnieae (and, oddly enough, of the uncorticated *Compsothamnion*) but of *Dasyptilon* alone among the Ptiloteae, which are otherwise parenchymatously corticated. In *Dasyptilon* the fertile axial cell becomes almost continuous with the gonimoblast, by a broadening of the pit-connections of the basal cell, and may die after the release of the carpospores, thus detaching the distal, uncorticated part of the shoot. Feldmann-Mazoyer suggests that, in *Seirospora Giraudyi*, the rhizoids may serve to anchor the detached apex as a new shoot. At any rate thay cannot be of more fundamental phylogenetic significance than the occurrence of rhizoidal cortication.

AFFINITIES OF DASYPTILON

The taxonomic position of *Dasyptilon* as a member of the Ptiloteae has never been questioned, but it has a number of features in which it is more referable to the Crouanieae, the tribe including the most generalized forms among the Ceramiaceae. In its distichous fronds, obliquely-dividing apical cell, relatively slight rhizoidal, non-parenchymatous cortication, and finally in the sessile lateral position of the tetrasporangia, it could be related to distichous species of *Antithamnion* among the Crouanieae. And these are the features on which Feldmann-Mazoyer distinguishes it from the other Ptiloteae. In sexual reproduction it shows features relatively generalized among the Ceramiaceae and shared by the Crouanieae, producing carpogonial branches on the pericentral cells of a modified shoot which retains the potentiality of vegetative development and resumption of the vegetative form in the absence of fertilization or, presumably, if detached after disintegration of the cystocarp.

Kylin (1930) separates the Ceramiaceae into two subfamilies: those with each procarp on a determinate axis, such as *Spermothamnion* and *Ptilota;* and those with procarps borne along an indeterminate axis. *Dasyptilon* with several procarps on a facultatively determinate axis thus links the two groups. However, the distinctive vegetative features of the Ptiloteae are found in the regular alternation of long and short branches on the axis, and the distinctive reproductive feature of the fertile pericentral cell producing carpogonial branch before sterile cell. Inasmuch as its features of specialization are those of the Ptiloteae, it

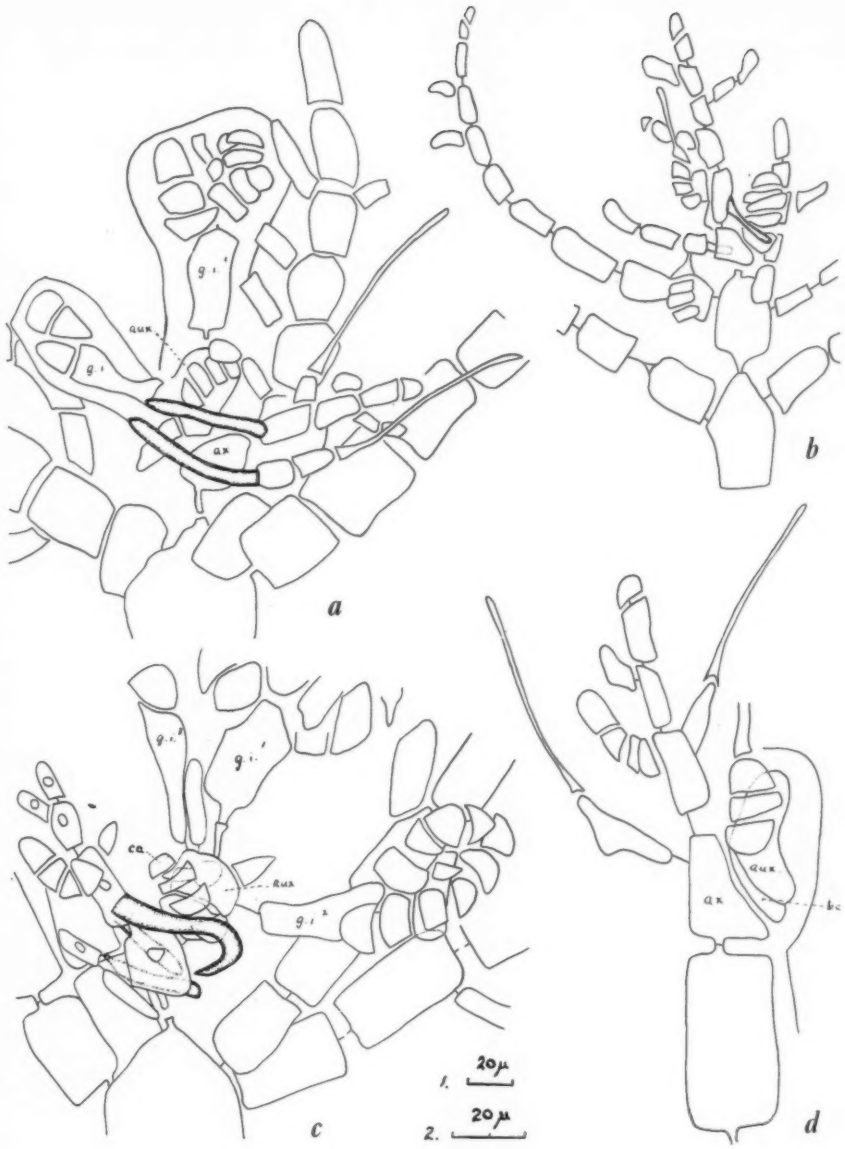

FIG. 2. *Dasyptilon pellucidum* (Harvey) Feldmann-Mazoyer. *a*, Cystocarp with girdling rhizoids; involucral branches four, one cut away to show apical part of shoot (Scale 2); *b*, fertile shoot shortly after fertilization of the middle carpogonium (Scale 1); *c*, base of a cystocarp with five gonimolobe initials (Scale 2); *d*, first post-fertilization stage: auxiliary cell just separated from pericentral cell, long shoots already tipped by hairs (Scale 2). *ax.*, axial cell (fertile); *aux.*, auxiliary cell; *bc.*, basal cell (of Oltmanns); *ca.*, carpogonium; *g.i.*, stalk cell of gonimolobe, in *c* numbered in order of development. The rhizoids are shaded.

may best be considered as the genus of the Ptiloteae least departing from the primitive condition of the Crouanieae.

In conclusion, I wish to acknowledge the invaluable assistance of L. A. Garay, who prepared the plates.

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North-South Differentiation of Blenniid Fishes in the Central Pacific

DONALD W. STRASBURG[1]

DIFFERENCES in the number of fin rays, scale rows, rings of bony armor (family Syngnathidae), and other meristic characters have long been employed as criteria for separating species and subspecies of fishes. With the recent increased interest in Central Pacific ichthyology numerous forms have been shown to exhibit minor differences in meristic characters between various geographical areas, and relatively extreme populations have been described as specifically or subspecifically distinct, depending upon the magnitude of the differences. The term *subspecies* has been a particularly popular one to apply to slightly divergent populations as it connotes both similarity and dissimilarity. In the Pacific, however, its use has been confusing from the standpoint of zoogeography, for often little or nothing has been said about gene interchange, effects of environmental factors, or method of distribution over vast expanses of ocean. For example, Herald (*in* Schultz *et al.*, 1953: 267, 273–275) distinguishes two subspecies of the pipefish *Corythoichthys flavofasciatus* on the basis of minor differences in meristic characters, and then says that the two forms are separated by a distance of 6,000 miles, with no other representatives of the species between them. A less extreme situation is Schultz's (*in* Schultz *et al.*, 1953: 292–297) erection of several subspecies of *Atherion elymus* based on slight differences in other meristic characters. In this case the forms occur in the Philippine, Marshall, and Mariana Islands, which are relatively close together compared to previous example, but considerable "island-hopping" must occur if there is interbreeding.

In the course of reviewing the blennioid fishes of the Hawaiian Islands the writer's attention has been drawn to a similar situation in that certain Hawaiian blennies bear a marked similarity to others from the Marshall Islands. The minimum distance between these two areas is about 1,400 miles, with practically no islands in between. Examination of specimens from Wake Island, one of the few intermediate geographical areas, indicated a rather surprising degree of intermediacy with respect to several morphological characters. Two hypotheses were formulated as a result of this discovery: 1) that there might be a traffic of fishes between the Marshalls and Hawaii by way of Wake, with a resultant possibility of gene interchange; and 2) that perhaps the intermediate nature of the Wake specimens was due to the intermediacy of some factor in the physical environment.

In considering the first hypothesis it is noteworthy that the prevailing ocean currents affecting the Hawaiian-Marshallese area act so as to move water from the Hawaiian Islands toward the Marshalls (Sverdrup *et al.*, 1946: chart 7). Consideration of this fact makes it obvious that if there is a movement of shore fishes between the Hawaiian and Marshall Islands it must normally be one-way, its point of origin being in Hawaii. If this is so then the high degree of endemism present in the Hawaiian shore fishes (reckoned as great as 52.6 per cent by Jordan and Evermann, 1905: 32) becomes a curious anomaly, as does

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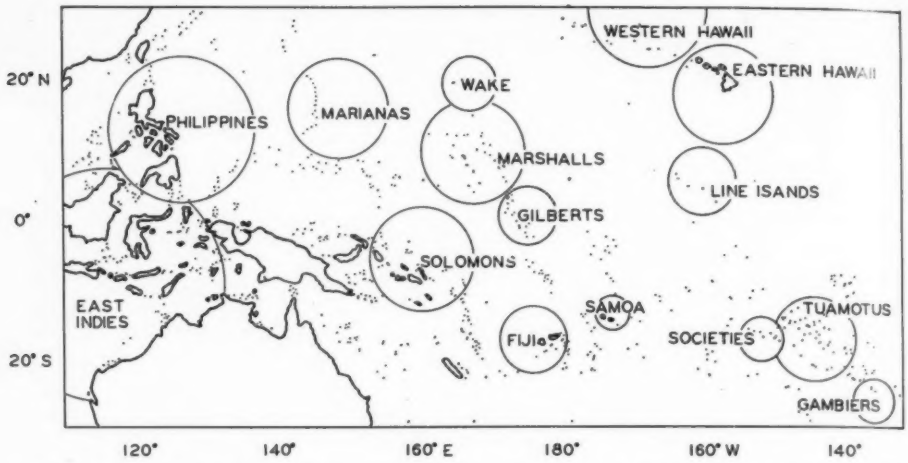

FIG. 1. Map showing relationships between various island groups of the Pacific Ocean. Circles denote areas from which specimens were examined.

the relatively distant relationship between the fishes of the Marshalls and Hawaii, as compared to the closer one between those of the Marshalls and the East Indies.

In order to investigate the second hypothesis the study was restricted to a single blenny, *Istiblennius edentulus*. This species is widely distributed throughout the Indo-Pacific region, but has evolved slightly different forms in certain isolated geographical areas. It, together with its close relatives, is a tidepool inhabitant and quite demersal in its habits. Spawning occurs in tidepools but the postlarvae are pelagic and are undoubtedly the stage in which dispersal of the species has occurred. Specimens from numerous island groups have been examined, and meristic data have been compared to an environmental condition, water temperature, in this work.

The writer wishes to thank Dr. Leonard P. Schultz of the U. S. National Museum, for making available the Museum's large store of Indo-Pacific blennies. Thanks are also due to Dr. William A. Gosline and Mr. John E. Randall, both of the University of Hawaii, for the loan of their collections of Wake Island and Gilbert Island blennies, respectively.

GEOGRAPHIC AND PHYSICAL CONSIDERATIONS

The Central Pacific Ocean, using the term rather loosely, is crossed by a band of islands running in a general southeasterly direction from the Marianas to the Gambiers (Fig. 1). This strip is about 5,500 miles in length and covers approximately 50 degrees (3,000 miles) of latitude. Its component islands are quite regularly spaced across the Pacific, and thus form a convenient array for a study of the effects of latitude, and hence temperature, on fishes. Because of the possibility of fish movement between islands in this band, with resultant interbreeding and masking of temperature effects, it was deemed advisable to study specimens from various remote geographical areas. The following list summarizes collection locales for specimens examined; those regions marked with an asterisk do not lie on or particularly near the main band of islands.

*Western Hawaii (Necker, Laysan)
*Eastern Hawaii (Oahu, Maui, Hawaii)
Wake
Marianas (Guam, Saipan)
*Philippines (Mindoro, Balabac)

Northern Marshalls (Bikini, Eniwetok, Kwajalein, Rongelap)
Southern Marshalls (Arno)
*Line Islands (Fanning)
Gilberts (Onotoa)
*Solomons (Bougainville, New Georgia, Nissan Group)
*East Indies (Java, Ste. Barbel)
Samoa (Apia, Tutuila)
Tuamotus (Fakarava, Makatea, Makemo, Rangiroa)
Fiji
Societies (Tahiti, Hereheretue)
Gambiers (Mangareva)

Inasmuch as the above band of islands crosses the Equator it is obvious that as a general rule sea temperatures will be greatest near its center and least as the northern and southern extremes are approached. Factors acting to offset this theoretical distribution are ocean currents and the seasons, each of which is somewhat variable in itself. These two factors, together with limited data on hydrographical conditions, make computation of accurate temperature values quite difficult. In this work surface water temperatures have been taken from Sverdrup, *et al.* (1946: charts 2 and 3), and approximations of means computed by averaging the values given for February and August. These means are listed in Table 1, together with other data.

FAUNAL CONSIDERATIONS

Istiblennius edentulus was described by Bloch (*in* Bloch and Schneider, Systema ichthyologiae, p. 172, 1801) from Huaheine Island in the Societies. Chapman (*in* de Beaufort and Chapman, 1951: 331) records its distribution from various localities throughout the Pacific and Indian Oceans and the Red Sea. He also mentions (*loc. cit.*) that the forms of the species occurring in southern Japan, Hawaii, and the Marquesas are probably subspecifically distinct from the one occupying the rest of the distribution. The Japanese and Hawaiian forms have been described as full species, *Istiblennius enosimae* (Jordan and Snyder, U. S. Nat. Mus., Proc. 25 (1293): 460, 1902), and *Istiblennius zebra* (Vaillant and Sauvage, Rev. Mag. Zool., 3 (3): 281, 1875), while the Marquesan form is as yet undescribed. Marquesan specimens were not available for this study, and Japanese material was not used because of the difficulty of obtaining precise water temperatures from along the coasts of Japan.

Principal differences between *edentulus* and *zebra* are the number of fin rays, the development of the fleshy crest on the heads of females, the presence of a tiny cirrus on each side of the nape, and the extent to which females are covered with small dark spots. Chapman (*loc. cit.*) admits the inconsistency of the color pattern as a means of separating Indian Ocean *edentulus* from those of the East Indies, and in the writer's opinion this character also is not valid in the Central Pacific.

The presence or absence of nuchal cirri has been studied, and appears to be an excellent criterion for distinguishing the Hawaiian representative from the other forms of *edentulus*. Cirri are never present in *zebra* (based on 244 specimens), but are always present in the true *edentulus* except for an occasional (injured?) specimen lacking the cirrus on one side. Such a loss occurs randomly throughout the distribution of the species, and is not restricted to specimens from areas near the Hawaiian Islands as might be expected.

The relative size of the cephalic crest in females is possibly a character worthy of further consideration. This crest is most prominent in *zebra*, and examination of large numbers of this blenny revealed that crest area is related to fish size but also varies somewhat at random. Insufficient material was available to determine the precise relationship of crest area to water temperature.

MERISTIC DATA

Table 1 summarizes fin ray counts made on *edentulus* and its close relative, *zebra*, for various portions of their ranges. It also includes mean counts for soft rays and data on

TABLE 1

COUNTS RECORDED FOR *Istiblennius edentulus* AND RELATIVES FROM THE PACIFIC OCEAN

LOCALE	NUMBER OF FIN RAYS																MEAN SURFACE TEMPERATURE (degrees C.)
	Dorsal fin									Mean soft rays	Anal fin						Mean soft rays	
	XI	XII	XIII	XIV	19	20	21	22	23		II	20	21	22	23	24		
Western Hawaii*		5	56	1			22	36	4	21.71	62		3	46	13		22.16	24.2
Eastern Hawaii*		1	171	10		1	28	134	19	21.94	182	1	4	112	64	1	22.33	24.8
Wake Island	1		17		1	8	9			20.44	18		3	9	6		22.17	26.2
Marianas			11		4	6	1			19.73	11		4	6	1		21.73	27.2
Philippines*		1	30	1	5	21	5	1		20.06	32		8	22	2		21.81	27.5
Northern Marshalls		1	20	1		20	2			20.09	22		4	16	2		21.91	27.2
Southern Marshalls			29	1	2	25	3			20.03	30		8	20	2		21.80	27.5
Line Islands*			2			2				20.00	2		1	1			21.50	26.2
Gilberts			3		1	1	1			20.00	3		1	2			21.67	28.0
Solomons*			11		2	8	1			19.91	11		3	8			21.73	28.0
East Indies*			4			3	1			20.25	4			4			22.00	28.0
Samoa		2	33	1	4	23	9			20.14	36	1	3	26	6		22.03	27.2
Tuamotus			5	1		4	2			20.33	6			4	2		22.33	26.2
Fiji			3			2	1			20.33	3			3			22.00	26.0
Societies		1	2			2	1			20.33	3		1	1	1		22.00	26.2
Gambiers			9	1		1	8	1		21.00	10			5	5		22.50	25.5

* Island groups not included in or near band of islands extending from Marianas to Tuamotus.

mean surface water temperature. These data have been arranged by latitude so that specimens from the northernmost islands (Western Hawaii) appear at the top, and those from the southernmost (Gambier Islands) at the bottom of the table. In counting, each fin ray with a separate and distinct base was listed as a single ray, and those rays split to a single base were also counted as one ray.

Inspection of Table 1 reveals a definite, but not absolutely regular, decrease in mean soft ray count as one goes from northern latitudes toward the Equator. Going south from the Equator the mean counts gradually increase, ultimately approaching or exceeding those found in the most northerly islands considered. Analysis of mean water temperatures shows that they follow the same general pattern.

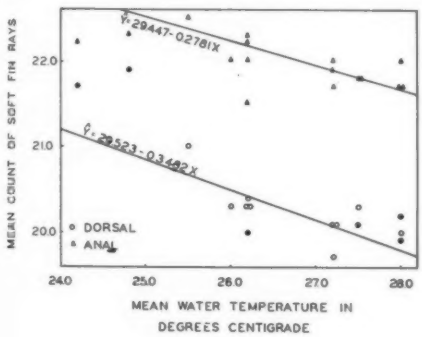

FIG. 2. Relationship between mean fin ray count and mean water temperature for *Istiblennius edentulus*. Hollow symbols represent data from main band of islands crossing Central Pacific (see text for details), solid symbols denote data from outlying islands. Regression lines calculated for main island band data only.

Figure 2 depicts the relationship between mean ray counts and mean water temperature, all figures here being rounded to one decimal place. Regression equations have been calculated for data from the main island band (excluding Western and Eastern Hawaii, the Philippines, the Line Islands, the Solomons, and the East Indies), and are as follows: $\hat{Y} = 29.523 - 0.3482X$ for the dorsal fin, and $\hat{Y} = 29.447 - 0.2781X$ for the anal fin. Since these two lines are approximately parallel it may be inferred that temperature has about the same effect on each fin.

It is noteworthy that certain of the points (solid symbols on Fig. 2) representing data from areas not on the main island band occur at considerable distances from the regression lines. Fiducial limits have been set for expected ray counts at various temperatures along the regression lines, using the formula $S_{\hat{Y}} = s_{yx}\sqrt{1/n + x^2/Sx^2}$ (Snedecor, 1946: 120) and values of t at the $p_{.01}$ level. These limits together with the actual ray counts are presented in Table 2.

From Table 2 it is apparent that fin ray counts of populations from various remote areas differ significantly from the values expected on the assumption of a linear relationship between ray counts and temperature. It is equally apparent that specimens from other remote areas have counts which are well in line with the expected figures. In the former category is Eastern Hawaii (dorsal rays), with Western Hawaii (anal rays) and the East Indies (dorsal and anal rays) being borderline cases. The Line Island data are based on only two specimens, and while their ray counts are significantly different from the expected values, the small sample size precludes emphasizing them.

DISCUSSION

It has been shown in Figure 2 that a close relationship exists between water temperature and fin ray count for *I. edentulus*. While the specimens upon which this conclusion is based came from a long chain of closely spaced islands it was also apparent (Table 2) that specimens from certain remote islands fitted quite well into this general picture. The Eastern Hawaiian Islands apparently represent a geographical region where other factors, presumably mutation, have offset the mean ray count from the expected values. Western

TABLE 2
ACTUAL MEAN RAY COUNTS AND EXPECTED RANGE IN MEAN RAY COUNTS FOR *Istiblennius edentulus* AND RELATIVES FROM OUTLYING ISLANDS

ISLAND	DORSAL FIN		ANAL FIN	
	Actual count	Expected range	Actual count	Expected range
Western Hawaii	21.7	20.3–21.9	22.2	22.2–23.2
Eastern Hawaii	21.9	20.3–21.5	22.3	22.1–23.0
Philippines	20.1	19.6–20.3	21.8	21.6–22.0
Line Islands	20.0	20.1–20.7	21.5	22.0–22.3
Solomons	19.9	19.3–20.2	21.7	21.4–22.0
East Indies	20.2	19.3–20.2	22.0	21.4–22.0

Hawaii and the East Indies are borderline instances of the same phenomenon, with the Line Islands possibly being so.

Several questions may be asked in connection with the above statements, probably the most important having to do with the validity of the supposed relationship between mean *annual* water temperature and the short period in ontogeny in which the number of fin rays is determined. Clearly this presumption can lead to certain errors, particularly in the case of fishes living in tidepools, the temperature of which is notoriously variable. Until further information is forthcoming on the embryology of Central Pacific fishes, however, mean temperature data must be used in working with museum specimens. Annual data are perhaps best since they average seasonal vicissitudes.

A second question which arises has to do with the taxonomic categories to be employed when dealing with a form showing meristic differences between various island groups. Obviously, if populations from areas representing extreme temperatures are considered they could be regarded as subspecifically distinct. When data are obtained from a more or less continuous series of islands, such as the band running from the Marianas to the Gambiers, however, it becomes apparent that extreme populations may be united by an evenly graded series. It is possible that specimens from an island in such a band are essentially ecotypes (as used by Dice, 1952: 397), but because of our lack of knowledge regarding the inheritance and adaptive significance of fin ray number this must be left as theory at present. It seems more credible that populations from a given locale actually represent ecophenes, that is, the precise number of their fin rays is affected by some environmental factor such as temperature. In their discussion of the response of ecophenes to their environment neither Dice (1952: 399) nor Allee *et al.* (1949: 626) mentions the heritability or adaptational value of the change wrought by the response, and in light of Tåning's experimental work (1944, 1952) it may probably be assumed that neither factor is involved in the case of *I. edentulus*. If populations within the major distribution of *edentulus* actually represent ecophenes then it would be superfluous to label them with any taxonomic category below the species.

A third question has to do with the possible presence of mutations affecting the number of fin rays. It may be argued that the clinal distribution of ray counts seen in Table 1 could be produced by the gradual spread of such mutations. If this were so then a mutation acting to decrease the number of fin rays would have to occur near the Equator in order to account for the symmetrical distribution of ray counts on either side of that region. Furthermore, it would also have to occur in the Philippines and the Solomons to account

for the low number of fin rays there. If the mutation acted to increase fin ray number then it would need to appear at both the northern and southern limits of the band of islands, again to explain the symmetry seen in Table 1. Because of the unlikelihood of these occurrences, as contrasted with the much more plausible temperature effects, mutation may probably be ruled out from the fin ray picture seen in the islands extending from the Marianas to the Gambiers.

It is very likely that *I. zebra*, the Hawaiian form of *edentulus*, was derived from a stock of *edentulus*-like blennies which acquired a high number of fin rays because of the temperature effects here discussed. Because of geographical isolation and mutation it subsequently evolved into its present form. Its lack of nuchal cirri, possession of a well-developed cephalic crest in females, and distinctive fin ray counts probably warrant its consideration as a full species.

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Geomorphic Contrasts Within the Koolau Range of Oahu, Hawaii

HAROLD S. PALMER[1]

LAYMEN AS WELL AS GEOLOGISTS have observed various striking topographic contrasts between the southeastern and the northwestern parts of the Koolau Range of the island of Oahu, Hawaii. These familiar contrasts are discussed in this paper, but attention is also called to certain less obvious contrasts, and to the bearing of all the contrasts on the geologic history of the Koolau Range.

I am indebted to Messrs. Doak C. Cox, Stephen B. Jones, Gordon A. Macdonald, Erik Palmer, Howard A. Powers, and Horace Winchell for careful reading of a draft and for valuable criticisms and suggestions.

In addition to the usual placing of references to the literature and to figures by items in parentheses, it was thought well to give help in locating of unfamiliar place names. Therefore references to the figures on which places may be found are given in parentheses after the place name in the text.

A chart was made of the 100-fathom and 200-fathom submarine contour lines around Oahu, but it showed no discernable contrasts between the two parts of the Koolau Range.

THE WINDWARD SIDE

Simplified maps of four parts of the windward, or northeast, side of the Koolau Range with a contour interval of 500 feet show significant contrasts (Fig. 1A–E). The southeastern part has rather continuous, high cliffs, that curve inland a little to form wide alcoves. Davis (1928: 171) aptly described these windward-facing cliffs as "receding in several bights between blunt cusps." At Waimanalo and Kailua (Fig. 1A) the alcoves or bights are a mile and a half to two miles wide, but those from Haiku Valley to Waiahole (Fig. 1B) are only a mile or a little less in width. In both these areas the reentrant depths of the alcoves are about three-quarters of a mile, and, because of the steepness of the cliffs, the 500- and 2,000-foot contour lines are in general only half a mile apart. For much of the way, a smooth curve generalizing the 500-foot contour line would depart from the actual contour lines by only a third or a half of a mile.

In the area from Kualoa to Kaluanui (Fig. 1C) narrow valleys are found instead of wide alcoves. At the ends of the ridges the 500-foot contour line is only a quarter of a mile from the shore, but it swings inland two or three miles in the valleys. Whatever cliffs there are, instead of facing the sea, face one another across deep valleys, strikingly, for example, near Sacred Falls in Kaluanui Valley.

From Hauula to the northwest end of the range (Fig. 1D) there are neither alcoves nor valleys with high and steep walls. Here the valleys are more numerous but shallower and narrower.

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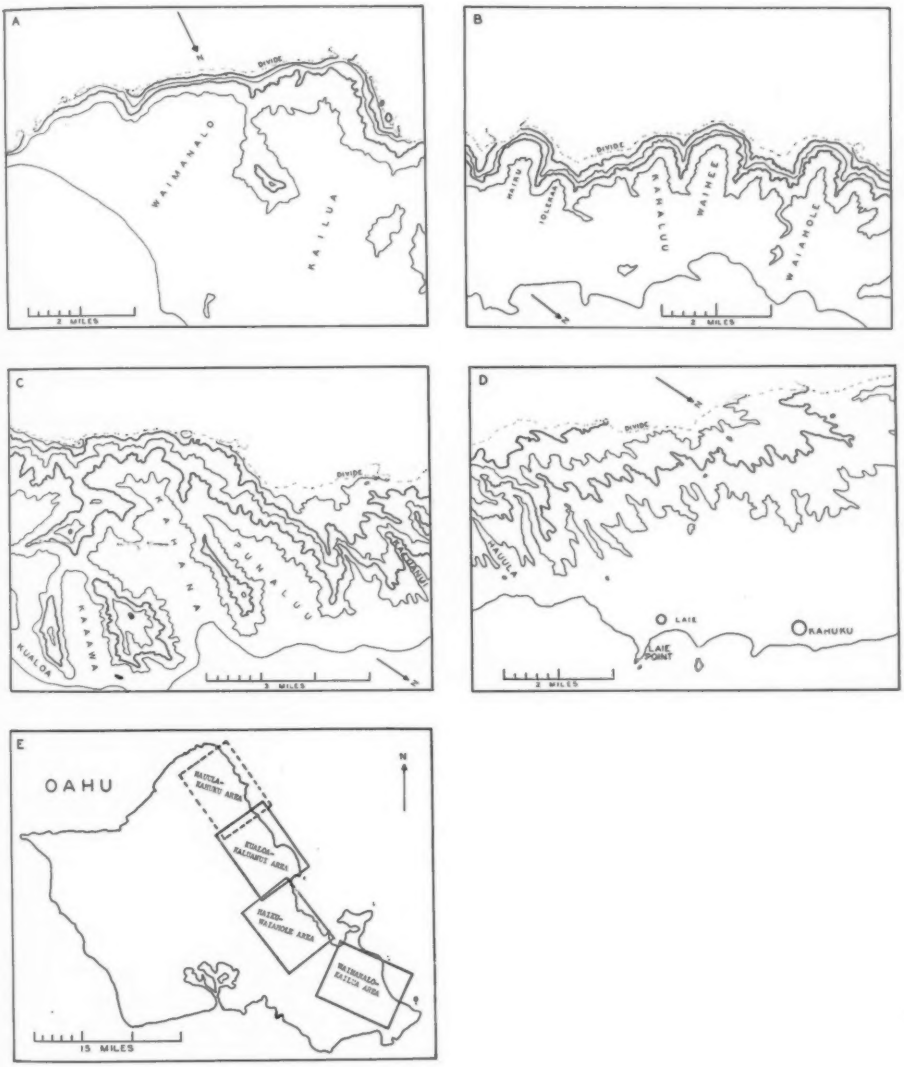

FIG. 1. Maps of the windward or northeast side of the Koolau Range. Contour interval 500 feet. A, the Waimanalo and Kailua area; B, the Haiku–Waiahole area; C, the Kualoa–Kaluanui area; D, the Hauula–Kahuku area; E, index map for A, B, C, and D.

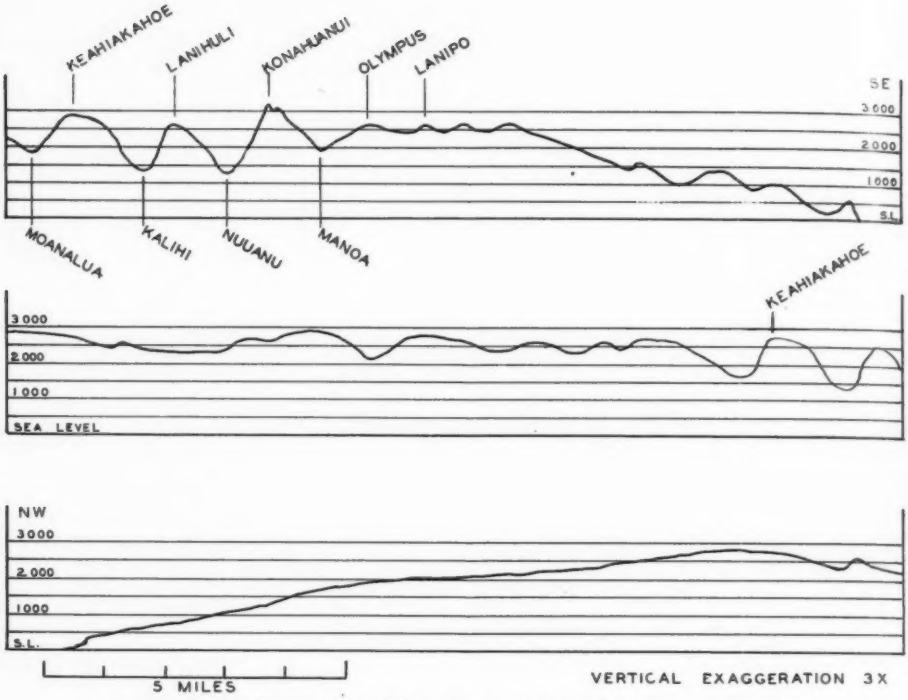

FIG. 2. Profile of the crest of the Koolau Range, with threefold vertical exaggeration.

The differences between these four areas are what would be expected if the southeastern end is the older and has thus been longer subjected to erosion. There is, of course, the additional difference that the high cliffs of the southeastern part may well be a strongly receded fault scarp.

THE SUMMIT REGION

The Crestline

The southeastern part of the crestline of the Koolau Range is deeply indented at the heads of the valleys that drain the leeward slopes, especially Manoa, Nuuanu, and Kalihi valleys (Figs. 2, 3, and 6B). The deep valleys and the deep indentations of the crestline imply prolonged erosion. In the five miles from Mt. Olympus to the head of Kalihi Valley, the crestline ranges from about 1,200 feet to 3,150 feet in altitude, a range of nearly 2,000 feet.

In contrast, the northwestern part of the crestline is only slightly indented (Figs. 2 and 4). No five-mile stretch of the crestline would range more than 1,000 feet, and perhaps no more than 500 feet in altitude. One infers that not enough time has elapsed, since constructional volcanic activity ceased, for streams to have worked headward so as to indent the crestline deeply.

The contrast in degree of indentation would be a normal consequence and indication of greater age of the southeastern end of the Koolau Range with its much deeper indentations of the crestline.

Areal Extent above 1,000 and Above 2,000 Feet

Altitudes over 3,000 feet are found in the Koolau Range only on Konahuanui (Fig. 2)

in the southeastern part. Obviously there was originally a considerable area above what is now the 3,000-foot level, most of which has been removed by erosion and perhaps in part by down-faulting. Though this part of the range still has the points of greatest altitude, it has much less area above either the 1,000-foot or the 2,000-foot contour lines than the northwestern part (Fig. 5). One may again

FIG. 3. Nuuanu Gap, a deep indentation of the crestline of the Koolau Range, as seen from the Hawaiian Pineapple Company cannery.

conclude that erosion has been at work much longer in the southeastern part, for it has been more fully and deeply dissected despite an originally greater altitude.

Dips of the lava flows suggest that the original summit lay distinctly northeast of the present crestline in the southeastern part of the Koolau Range, but close to the present crestline in the northwestern part of the range.

THE LEEWARD VALLEYS

The leeward valleys of the southeastern end of the range are notably wider, deeper and

FIG. 4. The smooth crestline of the northwest end of the Koolau Range, as seen from Laie Point.

flatter floored than the valleys of the northwestern end (Fig. 6A–E). These characters increase from Kalama Valley, northeast of Koko Crater, to Manoa or Nuuanu (Figs. 6A and 6B), perhaps because of greater stream erosion where higher altitude caused greater rainfall and provided larger collecting basins for streams (Fig. 7, isohyetal map of Oahu). In all this southeastern part of the Koolau Range, stream erosion has been able to cut so strongly partly because of greater steepness of the original slopes leading to greater velocity and thus to stronger erosional power.

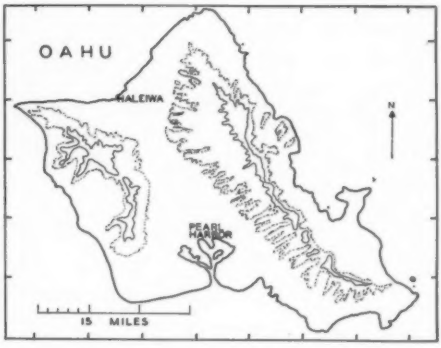

FIG. 5. The 1,000-foot (dotted line) and 2,000-foot (solid line) contour lines of Oahu.

The rather wide and level floors of Palolo, Manoa, Nuuanu and Kalihi Valleys (Fig. 6B) result in part from infilling by rather young intra-valley lava flows, but mostly from sedimentation in drowned valleys subsequent to a submergence of this part of Oahu. These valleys, and those to the east of Palolo, were cut to much their present form when this part of Oahu stood 800 or 1,000 feet higher relative to sea level than now, as shown by well logs in the Honolulu area (Palmer, 1946: 25–29). Subsidence changed the mouths of the valleys into bays, in whose quiet waters sediment accumulated to a considerable depth. Wailupe Valley (Fig. 6A) is a classic example of such a flattish valley floor (Davis, 1928: 174, fig. 74).

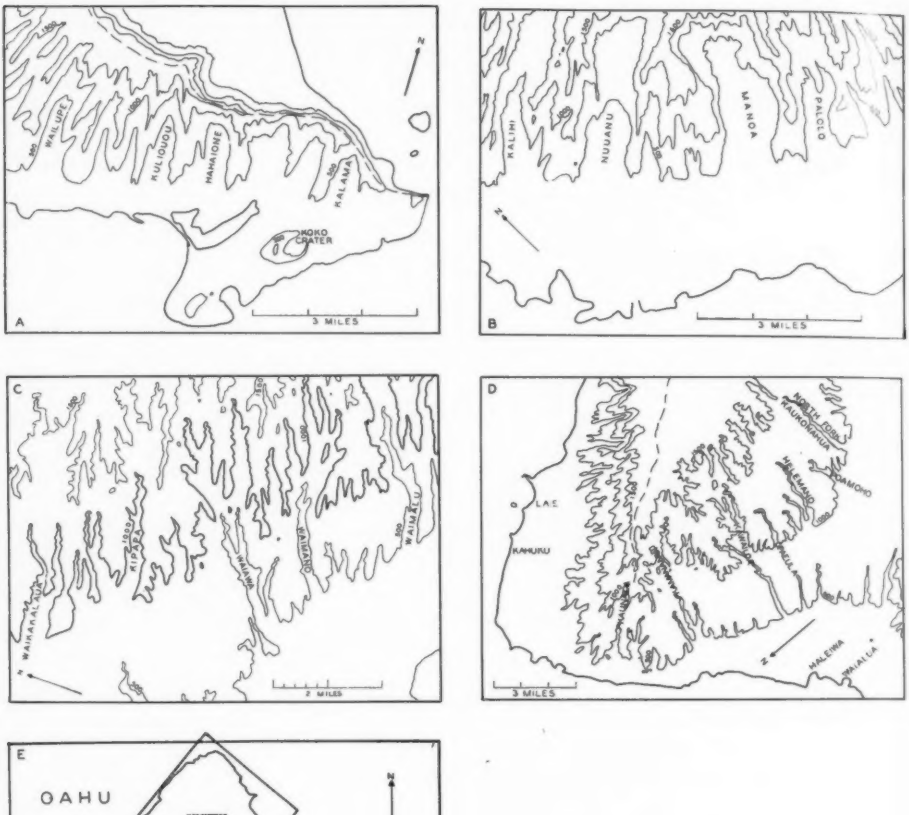

FIG. 6. Maps of the leeward valleys of the Koolau Range, 500-foot contour interval. A, The Kalama–Wailupe area; B, the Palolo–Kalihi area; C, the Waimalu–Waikakalaua area; D, the Kaukonahua–Kaunala area; E, index map for A, B, C, and D.

Subsidence also affected the part of the windward side from the southeastern end as far as Punaluu.

In contrast, northwest of Aiea (Fig. 6E) the leeward valleys are decidedly narrower and shallower, and to them the term "gulch" is usually applied instead of "valley" (Fig. 6C, D). Most striking are Kipapa, Waikakalaua, Kaukonahua, Poamoho and Helemano Gulches, whose sides drop rather abruptly

from a fairly smooth upland surface. The map of an area of five square miles southeast of Wahiawa (Fig. 8) shows part of the extensive, smooth upland used for pineapples, with Waikakalaua Gulch and the South Fork of Kaukonahua Gulch incised for more than a

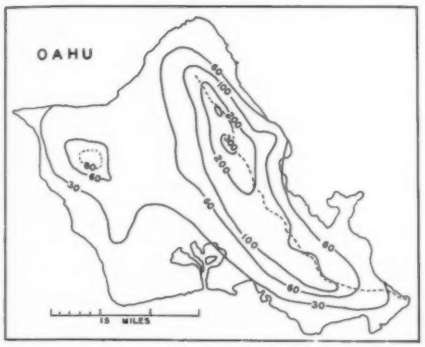

FIG. 7. Mean annual rainfall in inches on Oahu. (After the Territorial Planning Board, First Progress Report, pl. 52, p. 116. Feb. 1929.)

hundred feet. Here the upland slopes west or southwest about 200 feet to the mile, or about 2°.

In the northwestern part of the range the streams are much longer than those in the southeastern part, which operates in two ways to let only narrow gulches be cut. For one thing, the longer courses cause gentler gradients and thus less velocity and less erosive power. And also, the longer courses require the removal of a larger total volume for a given depth and width of valley, so that in a given time only narrower and shallower valleys will be cut than by shorter and steeper streams. All this is in addition to the present hypothesis that these streams have been at work for decidedly less time than the streams in the southeastern part of the range.

COURSES OF THE LEEWARD STREAMS

Comparison of two maps of the stream courses in areas, of about five square miles each, reveals marked contrasts between the ends of the Koolau Range (Fig. 9A, B). The Palolo–Waialae area, east of Manoa Valley, is characteristic of the southeastern end and the Kamananui area is characteristic of the northwestern end of the Koolau Range.

Where streams appear to have operated for a much longer time, east of Manoa, they have been able to eliminate much of their original windings in the process of cutting more and more direct courses to the sea. Their original steep gradients, down the flank of the highest part of the range, gave them greater speed and erosional energy that would favor straightening their courses.

In contrast, the streams from Kaiwikoele to Kaunala, of the northwestern Kamananui area, have much more winding courses. They began their work on less steep slopes and were therefore less strongly driven by gravity and meander more. Perhaps the gentle gradient even favors lateral swinging of the streams and meandering. When originally built the surface of a lava shield is far from smooth. Successive lava flows have steep edges and do not overlap perfectly. Their edges are

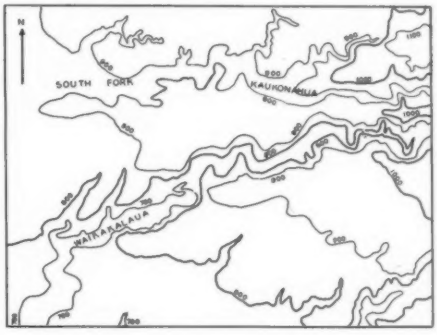

FIG. 8. Map of a smooth area of 5 square miles southeast of Wahiawa, with sharply incised gulches Contour interval 100 feet.

wavy, and these cause the streams to follow the irregularly winding low places between flows and thus to have winding courses at the start. It also appears that these streams have been at work for less time, and thus have had less time to straighten their courses.

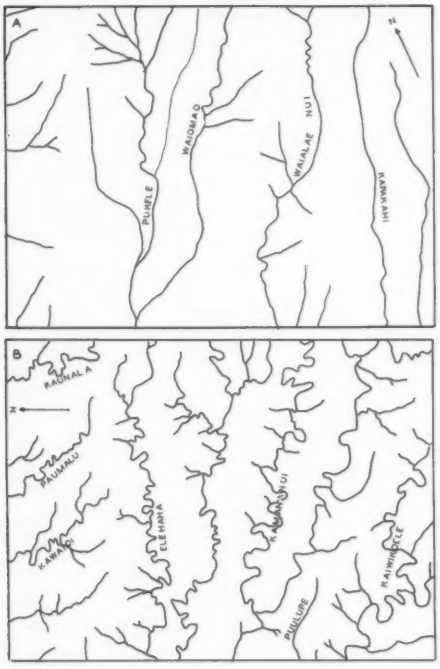

FIG. 9. Maps of stream courses, 2½ by 2.5 miles. A, Palolo–Waialae area (Pukele and Waiomao are branches of Palolo Stream); B, the Kamananui area.

CROSS PROFILES OF THE LEEWARD VALLEYS

The greater degree of dissection of the older, southeastern part of the Koolau Range, as compared to the younger, northwestern part, is shown by cross profiles constructed across several adjacent valleys and the intervening ridges. Two pairs of such cross profiles are given: one pair (Fig. 10A) closer to the sea, and one pair (Fig. 10B) farther inland. The lower profile of each pair is from the southeastern part of the range, and the upper profile is from the northwestern part.

The ridges of the southeastern seaward profile (Palolo to Kalihi, Fig. 6B) show only a few small remnants of the original surface as built up by superposed lava flows, but the northwestern profile (Poamoho to Kawailoa) is made up mostly of the lava-built surface.

The southeastern inland profile (Waiomao and Pukele to Kalihi) is far more deeply incised than the northwestern profile (North Fork of Kaukonahua to Kawainui). These contrasts in the inland profiles correspond, of course, to the contrasts still farther inland, namely the contrasts in indentation of the crestline of the range (Fig. 2).

LENGTHWISE PROFILES OF CRESTS OF LEEWARD RIDGES

Profiles constructed along the crests of ridges between valleys show a marked and significant difference between the two ends of the Koolau Range (Fig. 11). (Only three profiles are shown but they are representative of the eighteen that were constructed during this study.) The lower part of each profile shows approximately the surface as it was originally built up by lava flows. These lower parts have much less rainfall than the upper parts and are much less subject to weathering and erosion. They have, of course, been lowered a little, but the triangular facets that survive do preserve fairly well the original slope and form of the lava shield.

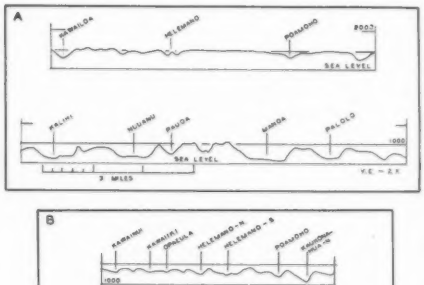

FIG. 10. Cross profiles of valleys. The upper of each pair is in the northwestern end and the lower in the southeastern end of the leeward slopes of the Koolau Range. A, Profiles farther seaward; B, profiles farther inland. Twofold vertical exaggeration.

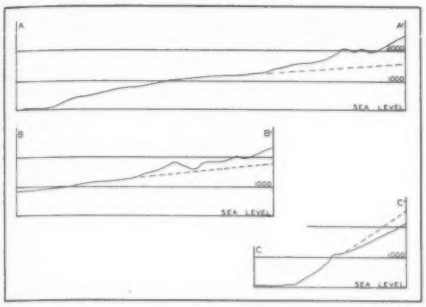

FIG. 11. Lengthwise profiles of three ridge crests. Vertical exaggeration about 5.2 times. See Figure 12 for the location of the profiles.

The profile along St. Louis Heights is what one would expect to find on a long eroded lava shield built as a *single* unit and with greater rainfall and greater erosion at the higher levels. Projection, or extrapolation, of the slope of the lower part of the profile, as shown by the broken line, runs distinctly *above* the much more eroded, much rainier, upper part of the profile.

In contrast, the profiles for the middle and northwestern parts of the range, one upslope from Wahiawa and one along the ridge on the south side of Helemano Gulch (Fig. 6D) are very different. Extrapolation of the slope of the lower part of each profile, instead of going above the rainier, more intricately dissected summit region, goes well *below* the crestline. This discrepancy leads to several hypotheses, which involve different constructional histories. The profiles are in a sense concave upward, at least for part of their extent. One thinks of lava shields as being convex upward in general, and it is the concavity that needs explanation.

Dr. Gordon A. Macdonald has pointed out to me in a letter that concave profiles are found on Hualalai, which might be due to maximum precipitation and erosion in the middle altitudes of that 8,251-foot mountain. This seems unlikely for the degree of dissection is rather uniform in all parts of Hualalai. He also points out concavities on the lower slopes of Mauna Loa, where lavas ponded against Mauna Kea, and on the lower slopes of Mauna Kea with similar ponding against the Kohala Mountains at the Waimea Saddle. In addition to these examples from the island of Hawaii, he wrote of similar concavity of the lower slopes of East Maui at the Isthmus and of East Molokai against West Molokai. An east-west profile of Mauna Kea shows concavity upward, but this may be due to the more viscous, later lavas coming to rest with steeper slopes than the older, more fluid lavas.

Ponding of lavas against the Waianae Mountains certainly has been a factor in limiting the extent of the gentle slopes of the lower parts of these profiles, as well as of the Wahiawa Plateau in general. However, there seems to be a fairly definite or sharp break in the slopes of these two profiles at about 1,200 feet altitude. Farther northwest, near Waimea Bay (Fig. 13), there is a fault with upthrow on the north side, which makes distinct breaks in profiles drawn at right angles *across* the ridge crests (Palmer, 1947, fig. 6).

The hypothesis is offered that the upper parts of these profiles (A—A′ and B—B′) represent an older long, narrow constructional land form, which was considerably eroded, and that subsequently younger volcanic activity discharged very fluid lavas that built the gentler slopes of the lower parts of the profiles. The upper parts are in regions of rather heavy rainfall and intricate dissection by streams, whereas the lower, drier parts are as yet but little dissected. These are the groups of lavas designated as K-2 and K-3 on the tentative map, Figure 19.

No petrographic evidence is known to me to indicate any marked difference in viscosity of lavas in these areas.

LATE VOLCANIC ACTIVITY

Three main volcanic episodes have long been recognized for Oahu. The first, which Stearns (1935) divided into three subepisodes, built the lava shield from which the Waianae Range has been carved. The second was

thought to have built the shield of the Koolau Range. In the third episode a number of pyroclastic cones and craters, such as Diamond Head, and several intra-valley flows were erupted, constituting the Honolulu Volcanic Series of Stearns.

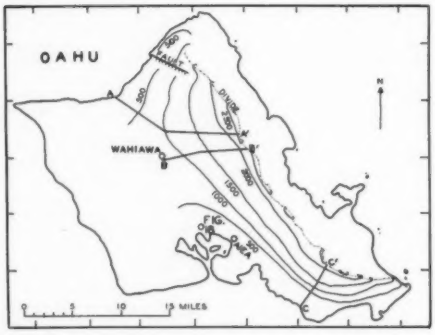

FIG. 12. Envelopes of the 500–, 1,000–, 1,500–, 2,000– and 2,500-foot contour lines on the lee side of the Koolau Range. The lines A—A¹, B—B¹ and C—C¹ show the locations of the profiles of Figure 11. Small circles give the locations of Wahiawa, Aiea, and the view in Figure 18.

One unexplained peculiarity of the last episode is that it seemed to be restricted to the part of the Koolau Range southeast of a line from Pearl Harbor to Kaneohe. (Several young structures lie on the south end of the Waianae Range, and may be of about the same age.)

Was anything happening northwest of that line?

The hypothesis here offered is that there was a large amount of eruptive action northwest of the line, more or less at the time that Diamond Head (Fig. 13) and the rest were active. At least this was after the Koolaus had been considerably eroded. This activity involved the quiet effusion of a large amount of very fluid lava, which flowed out to form very gently sloping surfaces. This hypothesis would account for the extensive, rather smooth, lava-built surface known to many as the Wahiawa Plateau. It would also explain the profiles of the ridge crests in the middle and northwestern parts of the Koolau Range. The vents that supplied these lavas would have been located more or less parallel to the Koolau crestline, but down the leeward side a way. If their altitudes were fairly low, like the altitudes of many of the vents of the Honolulu Volcanic Series, they would readily build a plateau that would overlap the lower slopes of the northwest end of the main Koolau Range, as it then was, filling in the valleys and partly burying ridges. The lavas, of course, also overlapped the lower slopes of the Waianae Range.

The southwest rift of Mauna Loa, on the island of Hawaii, is marked by cones, cracks, and fissures from which great volumes of lava

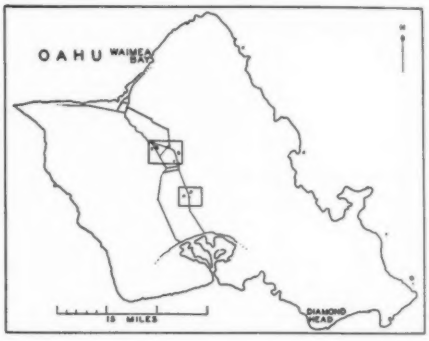

FIG. 13. Index map for Figures 14 and 16, the maps of lateral lava shields.

have been poured out to mantle the slopes of the mountain. The volume of lavas far exceeds the volume of pyroclastic materials erupted from the rift. At the south end, this rift on Mauna Loa is marked by a great fault at Ka Lae, with the shoreline of the downthrown, western side offset about two miles inland as compared to the upthrown, eastern side.

A rather similar fault offsets the shore line of Oahu about two-thirds of a mile at Waimea Bay (Fig. 12), at the northwest end of the Koolau Range. The similarity of the Waimea Fault to the Ka Lae Fault suggests that a rift extends eastward from Waimea Bay, and that it may well have determined the location of

the vents that yielded the lavas that built the Wahiawa Plateau and related, rather smooth surfaces.

ENVELOPES OF CONTOUR LINES

The levelness of the Wahiawa Plateau, or the gentleness of its slopes, is brought out by a study of the "envelopes" of the 500-,

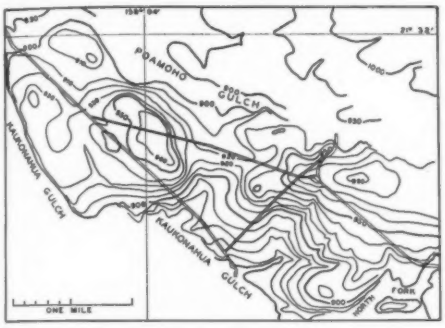

FIG. 14. Map of lateral lava shields northwest of Wahiawa. Contour intervals of 10 and 50 feet.

1,000-, 1,500-, 2,000- and 2,500-foot contour lines on the lee side of the Koolau Range (Fig. 12). The envelopes were constructed by marking the down-slope salients of the respective contour lines on the 1938 U. S. Geological Survey topographic map of Oahu, on the 1:62,500 scale. Then the salients were joined freehand by a smooth line, thus outlining the original form of the volcanic pile.

It will be noted that in the southeastern area the selected envelopes are only a mile or so apart, in general, indicating fairly steep slopes. In the northwestern part, however, they are in general twice as far apart indicating the gentler slopes of the suggested, additional volcanic episode.

LATERAL LAVA SHIELDS

There is no definite evidence as to the location of the eruptive vents that supplied most of the lavas that built the Wahiawa Plateau and its related surfaces. The suggested prolongation of the Waimea Fault as the locus of vents is only an hypothesis.

There are, however, certain minor, lateral vents indicated by half a dozen low but broad hills between Kipapa Gulch and Poamoho Gulch (Fig. 13). These small hills slope gently outward in *all* directions from their low summits, so that their slopes are in part in the reverse direction to the usual, roughly westward slope of the "plateau." Although they are much smaller they resemble to some degree the lateral lava shield named Maunaiki, which was built by a flank eruption from the southwest rift of Kilauea in the winter of 1919–1920. Lava that had drained from Halemaumau is thought to have moved underground along the rift for a way, and then to have come to the surface to build Maunaiki. Such structures are called lateral lava shields.

Three of the lateral lava shields, northwest of Wahiawa, are aligned as if their lavas had come from points along a rift or fissure bearing about N. 70° W. (Figs. 14 and 15). Two lateral lava shields, a little south of the Waiahole Aqueduct, one on either side of Kame-

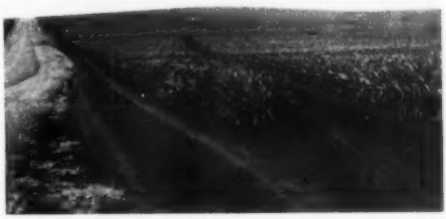

FIG. 15. The lateral lava shield in the northwest corner of the big triangle of roads in Figure 14.

hameha Highway, suggest a fissure bearing about S. 80° W. (Figs. 16 and 17).

Stearns (1940: 5 and pl. 1) suggested that the unexpectedly high ground water body, in the central part of the Wahiawa Plateau, was held up between dikes, and gave a map showing by two boundary lines the presumed extent of the high-level ground-water body.

The groups of small lava shields here described may well have been supplied with lava from such dikes. The dikes are, of course, transverse to the supposed rift that supplied most of the lavas for the Wahiawa Plateau.

The lava shields are too low to be shown by the 100-foot contour interval of the 1938 edition of the U. S. Geological Survey's topographic map of Oahu. It happens that the 40-foot interval of the 1917 U.S.G.S. map does have closed contour lines around four of the lava shields. The maps of Figures 14 and 16 were prepared from the photolithographic preliminary sheets for the 1938 edition. These preliminary maps are on the scale of 1:20,000, and have two contour intervals, 50 feet in the more rugged areas and only 10 feet in the smoother areas, which brings out the lava shields very clearly.

UNCONFORMITIES

In sedimentary rocks one often finds unconformities or marked differences between

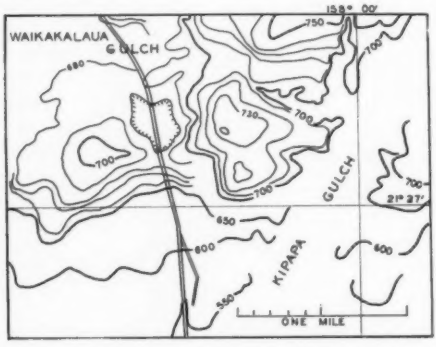

FIG. 16. Map of lateral lava shields between Kipapa and Waikakalaua Gulches. Contour intervals of 10 and 50 feet.

lots of strata deposited at different times. One lot may have a different attitude or inclination from the other, or they may differ in kinds of fossils, or kinds of rock, or the older may have weathered at its top to soil. Fossils cannot help in separating two lots of lavas made at different times, nor can differences in rock types often help in Hawaii where the rock

FIG. 17. The lateral lava shield east of the depression in Figure 16.

types are in general very similar. In a few places in Hawaii, however, older and younger lots of lava flows are separated by angular unconformities, where the older flows were truncated or bevelled and the newer flows mantled the eroded or faulted surfaces of the older flows. No such unconformities are known within the Koolau Range proper, although the Honolulu Volcanic Series lies unconformably on Koolau lavas in most places.

Some unconformities may have the older and younger lots of strata or lava flows in essentially parallel position, but with a deeply weathered zone at the top of the older series that implies a considerable time interval between the making of the older and the younger lots of rock. A possible example of such an unconformity has recently been exposed in a road cut on the north side of Kamehameha Highway about 0.7 miles west of Pearl City Junction (Fig. 18). This is not a conclusive example for it may be merely a lesser unconformity within one of the larger bodies of lavas.

GEOLOGIC HISTORY OF THE KOOLAU RANGE

The various topographic contrasts within the Koolau Range, to which attention has been called, lead to modifying the history of the Koolau Range as heretofore envisioned (Dana, 1890: 301; Dutton, 1894: 212–215; Hitchcock, 1900; Hitchcock, 1911: 42–44). (The history of the Waianae Range is omit-

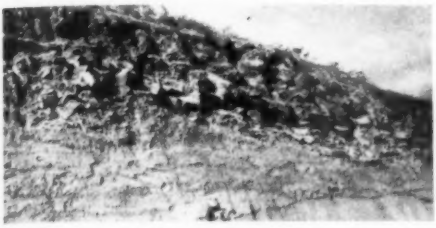

FIG. 18. Possible unconformity 0.7 miles west of Pearl City Junction. See Figure 12 for the location.

ted, except to note that the Waianae Lava Shield had been built and considerably eroded before the Koolau vents discharged any of the flows that overlap the east side of the Waianae Range.)

According to the new interpretation, the first Koolau episode was the building of the southeastern end of the present Koolau Range, making a somewhat elliptical dome or shield with a base of the order of 15 by 20 miles. The lavas of this episode are named "K-1" on the tentative map (Fig. 19). Flows on the leeward side dip 6° to 9° (Stearns, 1939, pl. 2). Those on the windward side presumably had similar dips, but this cannot be observed because so much of the original shield has been removed. When this eruptive activity died out, stream erosion became dominant and deep valleys were cut in the dome. It is my opinion that a considerable part of the windward side of this shield was dropped down along a fault or fault zone, and that the fault scarp has receded some miles as a result of various erosional processes.

Subsidence of part of the shield lowered the Honolulu area 800 or 1,000 feet. Data are not available for estimating the lowering in the Waimanalo and Kailua part of the windward side, but the fairly wide and level floors of Punaluu and Kahana valleys suggest subsidence of a few hundred feet, followed by sedimentation in the bays made by drowning the valley mouths. Northwest of Punaluu there is little or no evidence of significant subsidence of the windward side.

It is now suggested that a second episode of volcanic activity built a somewhat elongated ridge northwestward for 20 or more miles from the northwest end of the first oval shield. This ridge was about ten miles wide, and was built of the lavas that came up along numerous sub-parallel dikes of the "dike complex." It is indicated as "K-2" on the tentative map (Fig. 19). Though on a much smaller scale it is somewhat analogous to the ridge that has been built up by lavas from the southwest rift of Mauna Loa. Stearns (1939, pl. 2) reports dips of 7° to 10° on the windward side of this part of the Koolau Range. Data on dips are probably not obtainable on the leeward side, but are presumably similar.

Dividing the constructional history of the higher parts of the Koolau Range into two

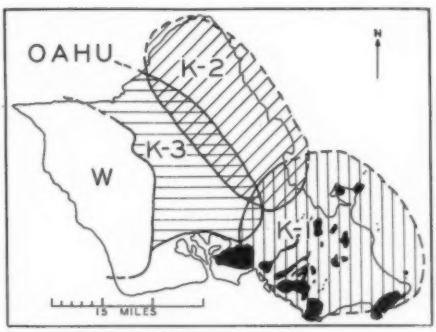

FIG. 19. Tentative map of areas built during the suggested eruptive episodes in the construction of the Koolau Range. The Honolulu Volcanic Series, solid black, is from Wentworth and Winchell (1947).

episodes, K-1 and K-2, will explain the contrasts between the southeastern and northwestern ends as regards (1) the windward aspect, i.e., alcoves vs. valleys, (2) the degree of indentation of the main crestline, (3) the relative amounts of area above the 2,000-foot level, (4) the shapes of the leeward valleys, and (5) the inland pair of cross profiles (Fig. 10B). The isohyetal map (Fig. 7) shows abundant, and about equally abundant, rainfall along the upper parts of the whole range, so that differences in rainfall cannot account for

the geomorphic contrasts. In fact, the areas of greatest rainfall, 300 inches a year, are in the less deeply eroded northwestern part.

After eruption of the K-2 series of lavas, there came another erosional episode, during which streams not only cut into this new ridge but also continued their work in the older part. Vigorous wave erosion may have commenced at this time or later, but the northwest end of the new ridge has been cut back by sea cliffs, which now survive as somewhat subdued cliffs from a little west of Kahuku nearly to Haleiwa (Fig. 6D). Wave action has also truncated various spurs on the windward side, especially from Kualoa to Hauula (Fig. 1C, D).

Next in our story, the last Koolau eruptive episode or episodes occurred. For one of these we have the "Honolulu Volcanic Series" of Stearns (1935) which built various pyroclastic cones and poured out several intra-valley lava flows in the Honolulu area, or the southeastern end of the Koolau Range. That the Honolulu Volcanic Series postdates the building of the southeastern part of the range is very clear from the unconformable positions and from the topographic youth of the cones, and flows.

The other late episode or sub-episode was the effusion of a large amount of very fluid lavas from the leeward side of the northwestern (K-2) ridge of the Koolau Range to build the smooth Wahiawa Plateau with gentle slopes leading not only toward the Waianae Range but also both ways, toward Pearl Harbor and toward Haleiwa, from the low divide between Waikakalaua and Kaukonahua streams. Small eruptions from transverse dikes or rifts built the various lateral lava shields. The lavas of the plateau and of the small shields constitute the K-3 series of the tentative map. There is no evidence in the structures by which to determine the relative age of the K-3 series and the Honolulu Volcanic Series, as they do not overlap, or no overlap of one on the other is exposed, nor is any recorded in well logs.

Perhaps the fact that pyroclastics are abundant in one and lacking in the other indicates that the two are of different age. Another difference is that the Honolulu Volcanic Series affected both the windward and leeward sides of the range, whereas the K-3 series is restricted to the leeward side.

An attempt to map the extent of the eruptive products of the several episodes must of necessity be tentative, because subsequent weathering and erosion have masked the former boundaries. To such extent as boundaries exist, they are those marked by topographic differences.

Separation of the K-3 and the K-2 lots of lava from one another will explain several topographic contrasts. The upper profile in Figure 10B is in the region of the K-2 Series, and has none of the original upland surviving as there is in the upper profile of Figure 10A, in the K-3 region. This, however, may be partly, or largely, a matter of differences in rainfall and in distance between stream courses. The profiles A—A′ and B—B′ in Figure 11 have a change of slope at the boundary between K-2 and K-3. And in Figure 12, the wide separation of the lower contour lines marks the area of the fluid K-3 lavas. Finally, the smoothness of the Wahiawa Plateau as a whole and the rather sharp incision of the gulches indicate the youth of the K-3 area as compared to the K-2 area.

The story concludes with the erosional episode that is going on at present. It continues the earlier erosional events on the older areas but began on the Honolulu Volcanic Series and on the K-3 Series when their eruptive activity ended. This episode is much complicated by the several glacially controlled oscillations of sea level, which are omitted as this paper is concerned primarily with the volcanic constructional events.

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Fishes Killed by the 1950 Eruption of Mauna Loa
III. Sternoptychidae[1]

JANET HAIG[2]

THE EXTENSIVE COLLECTION of fishes yielded by the Mauna Loa lava flow of 1950 included 45 hatchetfishes (Sternoptychidae) belonging to four species. They are of particular interest in view of the fact that two of these species have not hitherto been reported from the Hawaiian Islands, nor from anywhere in the central Pacific region. One species known from the Hawaiian Islands was not included in the collections.

Three of the hatchetfishes were cooked to the point where the flesh was falling off the bones, and were utterly unfit for detailed study, although still identifiable. A few more were in mediocre condition. The great majority, however, were in an excellent state of preservation, even retaining some of the thin deciduous scales which are usually lost in sternoptychids collected by the more conventional methods.

The five Hawaiian members of the family Sternoptychidae have all been described and figured elsewhere, some of them many times. For this reason it was considered unneccessary to include lengthy descriptions and detailed figures in this paper. Aside from original descriptions, the synonymies include references to Hawaiian localities only.

Sternoptychids are subject to great individual variation, the limits of which are still incompletely known, and data on this subject are useful in studies of the family. Measurements and counts for the lava flow material is therefore included in Table 1.

Particulars on the Mauna Loa lava flow and the collections appear in the first paper of this series (Gosline *et al.*, 1954).

The author is indebted to Dr. William A. Gosline for the opportunity to examine and report on this interesting collection, and to Dr. Leonard P. Schultz for supplying information on *Polyipnus nuttingi*.

KEY TO THE HAWAIIAN STERNOPTYCHIDAE

1. Eye normal; anal fin undivided 2
   Eye telescopic; anal fin divided; dorsal fin preceded by a transparent blade 3
2. An abrupt ventral constriction between trunk and postabdominal region, this space filled by a transparent integumentary plate; dorsal fin preceded by a transparent blade . . . . . **Sternoptyx diaphana**
   No abrupt ventral constriction between trunk and postabdominal region; dorsal fin preceded by a forked spine . . . . . **Polyipnus nuttingi**

[1] Contribution No. 155 from the Allan Hancock Foundation. Manuscript received August 30, 1954.

[2] Allan Hancock Foundation, University of Southern California, Los Angeles.

3. Photophores forming a nearly continuous series; two posterior abdominal spines, directed downward . . . . . **Argyropelecus affinis**
Photophores on postabdominal region in three groups 4
4. A large posterior abdominal spine, serrated and directed backward, often with a second small spine above it; groups of photophores on postabdominal region separated by wide interspaces . . . . . **Argyropelecus heathi**
Two posterior abdominal spines, directed downward, not serrated; groups of photophores on postabdominal region separated by narrow interspaces . . . . . **Argyropelecus sladeni**

Sternoptyx diaphana Hermann

Sternoptyx diaphana Hermann, 1781: 8, 33, pl. 1, figs. 1–2 (type locality, Jamaica).

Sternoptyx diaphana, Gilbert and Cramer, 1897: 416 ("Albatross" Sta. 3473, Kaiwi Channel, 313 fms.).

Sternoptyx diaphana, Gilbert, 1905: 609 ("Albatross" Stas. 3888 and 3904, off N coast of Molokai, 295–809 fms.; 3917, off S coast of Oahu, 294–330 fms.; 4005 and 4026, near Kauai, 368–1021 fms.; 4105, 4110, and 4111, Kaiwi Channel, 314–470 fms.; 4154, 4155, and 4166, near Bird Island, 293–1594 fms.).

Sternoptyx diaphana, Jordan and Seale, 1906: 190 (listed only).

Sternoptix diaphana, Jordan and Jordan, 1922: 9 (listed only).

Sternoptyx diaphana, Fowler, 1928: 35 (listed only).

Sternoptyx diaphana, Fowler, 1938: 265 (listed only).

MATERIAL EXAMINED: 14 specimens, 20.3 to 53.7 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Moore *et al.*, June 3, 1950.

7 specimens, 29.7 to 45.3 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Y. Yamaguchi, June 6, 1950.

2 specimens, 24.2 and 30.5 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Gosline, Hayes, Keen, and Ellis, June 6, 1950.

Gilbert and Cramer (1897: 404) noted that they did not see the *Sternoptyx* listed from "Albatross" Sta. 3474 in *U. S. Comn. Fish and Fisheries, Rpt. of the Commissioner* for 1892 (1894: 18). Two small *Sternoptyx diaphana* from this station are in the fish collections of the Natural History Museum of Stanford University, and bear catalog number 5697. "Albatross" Sta. 3474 is in Kaiwi Channel, 21°12′N × 157°38′30″W, 375 fms.

A lot of six small specimens in the Stanford collections, with catalog number 4928, is labelled "Albatross Stas. 2937 & 2808, Hawaiian Islands." There is also a label in the bottle stating "Bottle broken during earthquake." "Albatross" Sta. 2937 is in Kaiwi Channel, 21°14′06″N × 157°42′42″W, 47 fms. Sta. 2808 is in the open Pacific and not in the vicinity of the Hawaiian Islands. These two lots and their labels evidently became mixed as a result of the 1906 earthquake damage; and there is a possibility that the Sta. 2937 label was placed with the fishes by error, since it is unlikely that any of these specimens were captured at 47 fms. depth.

Sternoptyx diaphana has been reported from many parts of the Atlantic, Indian, and Pacific oceans. Some of the records may apply to *S. obscura* Garman, but it is questionable whether the latter should be retained as a distinct species. All the Hawaiian material examined is of the "*diaphana*" type with steeply inclined profile and large eye.

Polyipnus nuttingi Gilbert

Polyipnus spinosus, Gilbert and Cramer, 1897: 416 ("Albatross" Sta. 3476, S of Oahu, 298 fms.). Not *P. spinosus* Günther.

Polyipnus nuttingi, Gilbert *in* Jordan and Starks, 1904: 581 (mentioned in connection with a Japanese species).

Polyipnus nuttingi, Gilbert, 1905: 609, pl. 73 (type locality, "Albatross" Sta. 4088, in the approach to the Pailolo Channel between Molokai and Maui, 279–306 fms. Additional material, not designated as paratypes: "Albatross" Stas. 3867, Pailolo Channel, 284–290 fms.; 3920, off S coast of Oahu, 265–280 fms.; 4089, 4090, 4091, and 4097, approach to Pailolo Channel, 286–308 fms.; 4121, off the NW coast of Oahu, 216–251 fms.; 4134, vicinity of Kauai, 225–324 fms.).

Polyipnus nuttingi, Jordan and Seale, 1906: 190 (listed only).

Polyipnus nuttingi, Jordan, 1921: 646 (off SW shore of Hawaii, killed by a lava flow from Mauna Loa).

Polyipnus nuttingi, Jordan and Jordan, 1922: 9 (listed only).

Polyipnus nuttingi, Fowler, 1928: 35 (Alika, District of Kau, Hawaii; duplicate of the specimen reported by Jordan, 1921).

Polyipnus nuttingi, Schultz, 1938: 142, 145 ("Albatross" Sta. 4102, USNM 51593, probably by error; see discussion, below).

Polyipnus nuttingi, Fowler, 1938: 265 (listed only).

Polyipnus nuttingi, Böhlke, 1953: 17 (6 specimens from "Albatross" Stas. 3867, 4090, 4077, and 4121, Stanford Nat. Hist. Mus. cat. no. 8518, designated lecto-paratypes. "Albatross" Sta. 4077 is at the NE and N coast of Maui, 99–106 fms.).

Polyipnus nuttingi is not represented in the present collection, but is included here for the sake of completeness.

In Schultz (1938: 145), in the synonymy of *Polyipnus nuttingi*, appears the following entry: "*Polyipnus spinosus* (non Günther) GILBERT and CRAMER, U. S. Nat. Mus., vol. 19, p. 416, 1897 (U. S. N. M. no. 51593, cotypes, 33 specimens, 34 to 70 mm., *Albatross* station 4102, between Maui and Molokai Islands, Hawaii, 122 to 132 fathoms, July 23, 1902)." This is obviously an error, as Gilbert and Cramer (1897) made no reference to specimens from "Albatross" Sta. 4102. An inquiry to Dr. Schultz brought the reply that this record (in Schultz, 1938: 145) belongs in his preceding paragraph with U. S. N. M. 51599 (reference to Gilbert, 1905) and that his following paragraph ("U. S. N. M. no. 47720, one specimen, 41 mm., *Albatross* station 3476, latitude 21°09′N, longitude 157° 53′W., December 6, 1891") is the reference that should go with Gilbert and Cramer.

Gilbert (1905), however, made no reference to *Polyipnus nuttingi* from "Albatross" Sta. 4102, nor did any author subsequently until the publication of Schultz's paper. Dr. Schultz (*in litt.*) informs the writer that in the U. S. National Museum catalog, opposite no. 51593, "4102" is written in the "original number" column. At the time he wrote his paper Dr. Schultz assumed that this was an "Albatross" station number, but he now believes that this may be incorrect as the number 4102 was entered in different ink than the original entry and must have been added later. These specimens with catalog number 51593 are all contained in a single jar, with the original label in Gilbert's handwriting "*Polyipnus nuttingi* co-types," but without any "Albatross" station numbers.

Gilbert made his identifications at Stanford University and retained specimens from Stas. 3867, 4090, and 4121, as well as Sta. 4077 which was not included in his 1905 report. This material is still at Stanford, and was recorded by Böhlke (1953: 17) and seen by the present writer.

Dr. Schultz concludes that the remaining specimens, from Stas. 3920, 4089, 4091, 4097, and 4134, were wrapped by Gilbert in a single package with one label and sent back to the U. S. National Museum. Apparently, then, number "4102" was applied in the U. S. National Museum catalog to an aggregate of 33 specimens from several stations and

TABLE 1

MEASUREMENTS* AND COUNTS OF HAWAIIAN STERNOPTYCHIDAE

	S. diaphana	*A. affinis*	*A. heathi*	*A. sladeni*
Head	286–332	281–343	298–358	324–364
Orbit	161–210	124–140	142–157	132–155
Snout	46–72	75–90	86–108	66–92
Gape	198–261	232–261	250–274	258–289
Snout to D origin	630–764	470–490	461–543	502–543
Snout to V origin	539–670	568–640	555–591	615–675
Snout to P origin	278–459	311–405	330–362	338–399
Snout to A origin	542–693	628–679	590–645	639–706
1st D ray to ant. abdominal spine	875–1065	531–605	555–591	604–656
1st D ray to post. abdominal spine	800–989	352–433	414–466	511–541
D ray 1 to A ray 1	725–890	318–347	268–308	403–433
Ant. abd. spine to post. abd. spine	262–413	385–423	355–374	386–417
Ht. dorsal blade	164–242	24–37	59–82	29–50
Dorsal rays	10–11	9	8	9
Anal rays	13–15	13	11	11–12
Pectoral rays	9–11	11	11	9–11
Ventral rays	5	6	6	6
Gillrakers	11–17 (5–7+ 6–10)	17–22 (7–9+10–13)	19–21 (8–9+11–12)	18–20 (8–9+10–11)

* Measurements are given in thousandths of the standard length. They reflect the great intraspecific variation occurring in fishes of this family, even within a restricted geographical area; and point up the fact that caution must be used when one attempts to separate species on the basis of proportional differences.

does not represent an "Albatross" station number.

Schultz (1938: 142) gave the locality "south of Minamitori Shima, Marcus Islands" for this species, in addition to the Hawaiian Islands. Being unable to locate this reference in the earlier literature, the present writer consulted Dr. Schultz, who replied (*in litt.*) that he is unable to verify the Marcus Island locality and that for the present it should be considered an error. Matsubara's (1950) statement that the species occurs in Japan was probably based on Schultz's record. Norman (1939: 20) reported it from the Zanzibar area, basing his identification on Schultz's revision of the genus.

Argyropelecus affinis Garman

Argyropelecus affinis Garman, 1899: 237 (type locality, "Albatross" Sta. 2117, off Bird Island in the West Indies, 683 fms.).

MATERIAL EXAMINED: 2 specimens, 40.3 and 58.3 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Y. Yamaguchi, June 6, 1950.

1 specimen, 59.5 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Gosline, Hayes, Keen, and Ellis, June 6, 1950.

Argyropelecus affinis has been recorded from the Indian and the north and south Atlantic oceans, and the writer has seen considerable material from the eastern Pacific. However, until the present time it has not been reported from the central Pacific region.

Argyropelecus heathi Gilbert

Argyropelecus heathi Gilbert, 1905: 601, pl. 72, fig. 1 (type locality, "Albatross" Sta. 4107, Kaiwi Channel, between Oahu and Molokai, 350–355 fms.).

Argyropelecus heathi, Jordan and Seale, 1906: 190 (listed only).

Argyropelecus heathi, Jordan and Jordan, 1922: 9 (listed only).

Argyropelecus heathi, Fowler, 1928: 35 (Alika, District of Kau, Hawaii).
Argyropelecus hemigymnus, Schultz, 1938: 146, 148 (listed from Hawaiian Islands). Hawaiian records not *A. hemigymnus* Cocco.
Argyropelecus heathi, Fowler, 1938: 265 (listed only).

MATERIAL EXAMINED: 3 specimens, 20.3 to 27.6 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Y. Yamaguchi, June 6, 1950.

1 specimen, 30.3 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Gosline, Hayes, Keen, and Ellis, June 6, 1950.

The only previously known specimen of this species in addition to the holotype was recorded by Fowler (1928). This specimen, which was killed by the Mauna Loa lava flow of 1919, was presented by the collector to the Bernice P. Bishop Museum and thus was not among the fishes reported by Jordan (1921) from that lava flow collection.

Although not reported in the literature from any area outside of the Hawaiian Islands, the species is also known from the eastern Pacific on the basis of records as yet unpublished.

The reasons for retaining *Argyropelecus heathi* as a separate species from *A. hemigymnus* Cocco will be discussed in a forthcoming paper by Dr. Rolf L. Bolin and the present writer.

Argyropelecus sladeni Regan

Argyropelecus sladeni Regan, 1908: 218 (type locality, Salomon, Chagos Archipelago, Indian Ocean, 400–500 fms.).

MATERIAL EXAMINED: 1 specimen, 64.4 mm. in standard length, taken off the Mauna Loa lava flow, Hawaii, by Hayes and Burke, June 2, 1950.

3 fragmented specimens, taken off the Mauna Loa lava flow, Hawaii, by Moore *et al.*, June 3, 1950.

10 specimens, 47.4 to 75.9 mm. in standard length, plus 1 fragmented specimen, taken off the Mauna Loa lava flow, Hawaii, by Y. Yamaguchi, June 6, 1950.

Opinion differs among various authors as to the status of several closely related *Argyropelecus* species, of which *A. sladeni* is one (Norman, 1930: 301, 304, text fig. 13; Parr, 1937: 46, 50, text figs. 18, 19; Schultz, 1938: 147, 153). Until collections from all parts of the world are compared, this problem cannot be resolved. However, the Hawaiian specimens are of the relatively slender-bodied type with long upper preopercular spine and low dorsal blade, and fall within the limits of *A. sladeni* as interpreted by all three of the authors cited above. It seems best to assign them to this species for the present.

A. sladeni, as presently defined, is known from the Atlantic, Antarctic, Indian, and east and west Pacific oceans. It has not previously been reported from the Hawaiian Islands or anywhere in the central Pacific area.

RELATIONSHIPS

Aside from those pertaining to the Hawaiian Islands, there are no published records of hatchetfishes from the central Pacific region. Nevertheless it is probable that future collecting will add several more species to the five now known from this area. In view of the fact that most sternoptychids are very widely distributed, occurring in several of the great oceans, it would be difficult to make a general statement as to the relationships of the central Pacific sternoptychid fauna or to predict which species would be most likely to be found there in the future.

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The Land Mollusca of Nissan Island, Solomon Islands

R. K. DELL[1]

IN THE COURSE OF WAR SERVICE in the Solomon Islands the writer spent several months in 1944 on Nissan Island (Green, or Sir Charles Hardy, Island) in the northern Solomons. A large collection of Mollusca was made and the present work is based on the land Mollusca obtained. The geographical position of Nissan on the island arc between the Solomons and New Ireland makes the fauna of some interest in a consideration of the origin of the Solomon Island fauna.

LIST OF THE SPECIES

Leptopoma vitreum (Draparnaud, 1801).
Pupina keraudreni Vignard, 1829.
Sturanya modesta (Pfeiffer, 1853).
Pseudocyclotus levis levis (Pfeiffer, 1853).
Omphalotropis nebulosa Pease, 1872.
Paludinella solomonensis n. sp.
Syncera nitida guamensis Abbott, 1945.
Orpiella (*Owaraha*) *nissani* n. sp.
Eustomopsis eustoma (Pfeiffer, 1856).
Papuina (*Pinnadena*) *periwonensis* n. sp.
Gyropena nissani n. sp.
Partula c.f. carteriensis (Q. and G., 1832).
Opeas gracile (Hutton, 1834).

Leptopoma vitreum (Draparnaud, 1801)

Jutting (1948: 566) cites *vitreum* as of Draparnaud, 1801, (*Tabl. Moll. France*). Iredale (1941) cites *vitreum* as of Lesson, 1830, and considers that Lesson's name was preoccupied by that of Draparnaud. He therefore uses *nitidum* of Sowerby for this series. Jutting has apparently considered that the two names apply to the same species and that there is therefore no need to alter the name. The writer has been unable to see Draparnaud's work, therefore, Jutting's usage will be followed.

The group of forms around *vitreum* and *nitidum* are widely distributed in the Austro-Malayan area. Bartsch (1918) differentiated sixteen subspecies from the Philippines and Iredale (1941) indicates two subspecies from New Guinea. Populations from various localities in New Britain and the Solomons do show proportional differences but insufficient material is available to determine whether these apparent geographical differences are constant.

This species occurred rather commonly on Nissan Island, living on the leaves of low shrubs. The shell dimensions of three specimens are:

Height (mm.)	Diameter (mm.)
12.3	12.1
10.6	10.0
10.0	10.4

Pupina keraudreni Vignard, 1829

A series from rotten logs near the shore at Tangalan Plantation, Nissan Island, agrees

[1] Dominion Museum, Wellington, New Zealand.
Manuscript received November 9, 1954.

TABLE 1

SHELL DATA OF *Paludinella solomonensis* n. sp.
(Measurements in Millimeters)

	HOLOTYPE	PARATYPE
Height	2.36	2.77
Diameter	1.36	1.91
Height of Body Whorl	1.91	2.08
Height of Aperture	1.36	1.41

very well with *P. keraudreni* Vignard, the type species of the genus. This species occurs also in New Guinea (type locality), New Britain, and throughout the Solomons to Santa Anna in the southeast. Clench (1949: 33) notes that *P. solomonensis* Smith is very close to *P. keraudreni*. The differences given by Clench, larger size and dark coloration, do not appear very valid differences and probably only one form is represented.

Sturanya modesta (Pfeiffer, 1853)

This was the only member of the Helicinidae collected on Nissan. It was common throughout the island on low vegetation. Rensch and Rensch (1936: 683) record it from Shortland Island, New Georgia, Guadalcanal in the Solomons, the New Hebrides (type locality), and Samoa.

Pseudocyclotus levis levis (Pfeiffer, 1855)

This species occurred not uncommonly on Nissan on leaves of living vegetation. It occurs through the Solomons from the north to Santa Anna in the southeast. Rensch (1937: 616) also records it from New Ireland.

Omphalotropis nebulosa Pease, 1872

Smith (1855: 597) has shown that *nebulosa* Pease should be used for the Solomon Island shells instead of *bulimoides* H. & J., which refers to a species from the Caroline Islands. Rensch and Rensch (1931: 684) have followed this usage. This species was commonly distributed under logs and leaves on the forest floor on Nissan. It appears to be distributed throughout most of the Solomon Islands. It has also been recorded from the Bismarck Archipelago by Rensch (1937: 620).

Paludinella solomonensis n. sp.
Fig. 1*d*

Shell small, 2.3 to 2.7 mm. long, globose, light brown in colour, smooth and semi-translucent. Protoconch of one and a half smooth shining whorls. Post nuclear whorls with very fine microscopic spirals on early whorls, becoming obsolete over adult whorl surfaces. Number of whorls five and a half. Outline of whorls rather broadly rounded. Body whorl slightly subangled below the middle. Sculpture consisting of irregular axial growth lines with traces of fine spirals on the base. Suture slightly impressed. Aperture obliquely ovate, constricted above. Outer lip thin, sharp. Parietal wall gently concave. Columella short, rounded. There is a well-marked constriction of the aperture edge at junction of parietal wall and columella. Umbilicus completely obscured by thickened columella. Shell measurements are given in Table 1.

Locality: Near lagoon shore, Tangalan Plantation, Nissan Island. R. K. Dell, 1944.

Holotype (M. F. 2509) and paratype (M. F. 2510) in Dominion Museum, Wellington, New Zealand.

This appears to be the first record of the genus from the Solomons. The outline characterizes the species.

Syncera nitida guamensis Abbott, 1949
Fig. 1*b*

A series of shells from near the lagoon shore, Tangalan Plantation, Nissan Island, cannot be separated from the above subspecies from the Marianas. The umbilicus is totally closed in all the specimens seen. Half-grown specimens have a low spiral carina on the base. Abbott's figure (1949, fig. 8) of

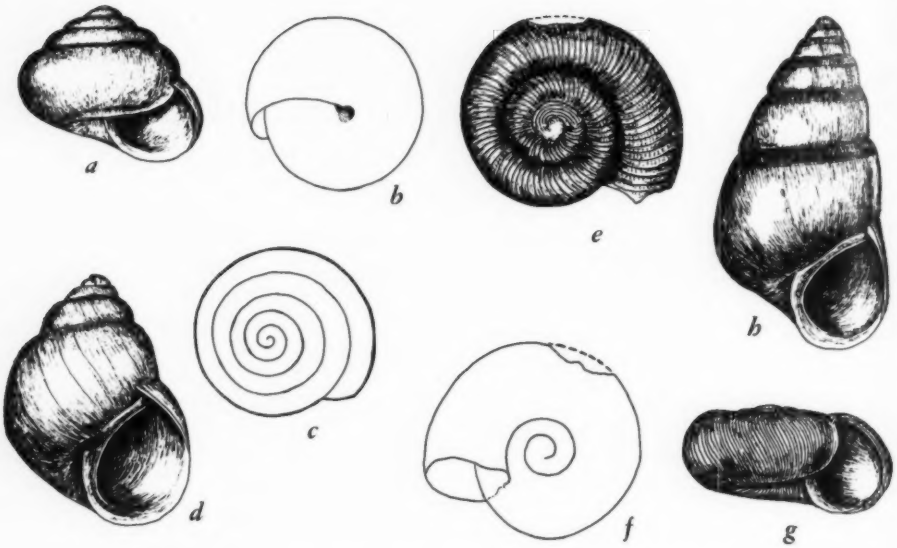

FIG. 1. *a–c*, Frontal, basal, and apical aspects of the shell of *Orpiella* (*Owaraha*) *nissani* n. sp. (holotype, 3.04 × 2.32 mm.). *d*, The shell of *Paludinella solomonensis* n. sp. (holotype, 2.36 × 1.36 mm.). *e–g*, Apical, basal, and frontal aspects of the shell of *Gyropena nissani* n. sp. (holotype, 2.04 × 0.92 mm.). *h*, The shell of *Syncera nitida guamensis* Abbott (Nissan Island, 3.18 × 1.86 mm.).

guamensis shows a wider shell than the Nissan specimens but his measurements indicate that both forms have almost identical proportions. Since later work may show that the Solomon Island form is separable, a specimen from Nissan is figured and the dimensions of five specimens are given below.

HEIGHT (mm.)	DIAMETER (mm.)	HEIGHT OF BODY WHORL (mm.)	HEIGHT OF APERTURE (mm.)
3.18	1.86	2.0	1.27
2.73	1.59	1.77	1.13
2.59	1.73	1.73	1.13
2.95	1.68	1.77	1.13
2.95	1.73	1.86	1.13

Genus ORPIELLA Gray, 1855

1855 *Orpiella* Gray, *Pulm. Brit. Mus.*, p. 147.
Haplotype: *Helix scorpio* Gould.

Baker (1941: 239) gives a full synonymy for this genus. He also proposes (p. 240) a new section, *Owaraha* for *Helix solidiuscula* Smith from the Solomon Islands, and this name probably is available for all the Solomon Island species, previously assigned to *Fretum*, *Kalendyma*, and *Nanina*. Rensch and Rensch (1936) has used *Orpiella* for *compluviata* (Cox), *concava* (Clapp), *malaitaensis* (Clapp), *treasuryensis* (Tryon), *pamuaensis* (Clapp), *keppelli* (Pfeiffer) and *solidiuscula* (Smith).

A small species was obtained on Nissan which does not agree with any other species recorded from the Solomons. It is here described as new. In the absence of the animal it may be tentatively assigned to *Orpiella* (*Owaraha*).

Orpiella (Owaraha) nissani n. sp.

Fig. 1*a–c*

Shell small globose-turbinate, perforate, translucent, shiny brown. Whorls five and a half, narrowly increasing, periphery evenly rounded. Embryonic whorls sculptured with microscopic spirals crossed by axials of

weaker strength. This sculpture persists across the spire whorls, with irregular axial growth wrinkles becoming more apparent. On the base the fine spirals become somewhat irregular but are stronger, and the microscopic axials become obsolete. Spire somewhat elevated. Suture rather impressed. Aperture sublunate, slightly oblique. Outer lip simple. Columella obliquely descending, slightly thickened and reflexed, almost covering the umbilicus. Umbilicus very narrow, deep, almost covered by the reflected columella.

Maximum diameter, 3.04 mm.; height, 2.32 mm.; height of spire 1.0 mm. (Holotype). Dimensions of three paratypes, maximum diameter 2.64, 3.0, 2.64 mm.; height, 1.91, 2.36, 1.86 mm.; height of spire 0.73, 1.19, 0.82 mm., respectively.

Holotype (M. F. 2511) and two paratypes (M. F. 2512) in Dominion Museum, Wellington, New Zealand. Another paratype in Bernice P. Bishop Museum, Honolulu.

Locality: Tangalan Plantation, Nissan Island, Solomon Islands, under logs. R. K. Dell, –6–1944.

Eustomopsis eustoma Pfeiffer 1856

A single shell was obtained from Nissan. It has the raised spire of *erinaceus* Pfr. but the whole question of the subspecific status of the Solomon Island forms needs review. Present indications are that *Eustomopsis eustoma erinaceus* Pfr. may be a northern form extending to New Ireland with *Eustomopsis eustoma eustoma* Pfr. replacing it in the southern Solomons. Only extensive series from numerous localities can decide the matter. It may well be a case of variability with no geographical basis.

Papuina (Pinnadena) periwonensis n. sp.
Fig. 2*b–d*

Shell trochiform, periphery sharply angled, imperforate. Whorls four and a half. Protoconch not clearly marked off from subsequent whorls. Apex domed, smooth at first apart from fine growth wrinkles. Upper whorls with fine irregular incised spirals which are retained on lower whorls on a narrow band below the suture. Penultimate and body whorl above the peripheral keel sculptured with irregular closely spaced oblique wrinkles. Base of body whorl with raised wrinkles, with irregular raised spirals running through them. Body whorl divided about the middle with a strong raised keel. Aperture oblique, expanded, thickened. Outer lip angled slightly by the keel, bearing up to three low broad teeth above the angulation. Outer lip advanced, columella retracted. No sign of perforation. Colour yellowish cream with broad irregular, brown, axially disposed, zigzag markings on the spire whorls, becoming rather oblique on the body whorl. Outer lip, columella and edge of keel white. See Table 2 for shell measurements. Locality: On vegetation near Periwon Village, Nissan Island, northern Solomons, R. K. Dell, May, 1944; generally distributed in the area near Tangalan Plantation.

Holotype (M. F. 2507) and four paratypes (M. F. 2508) in the Dominion Museum.

There is some variation in regard to height-width ratios and the brown colour markings are less obvious in some examples. Pilsbry

TABLE 2
SHELL MEASUREMENTS OF *Papuina* (*Pinnadera*) *periwonensis* N. SP.
(Measurements in Millimeters)

	DIAMETER	HEIGHT	HEIGHT OF SPIRE
Holotype....	28.0	19.1	9.5
Paratype.....	27.8	19.5	10.2
Paratype.....	26.3	19.5	10.7
Paratype.....	27.4	18.5	10.1
Paratype.....	25.2	19.0	9.2

(1891) gave Marten's genus *Papuina* subgeneric rank and used some 15 groups, for each of which he gave a short diagnosis. Later workers have restored *Papuina* to full generic rank. Iredale (1941: 84) has proposed new generic names for 14 of these groups and has

used Pilsbry's group diagnoses as generic diagnoses without any very critical re-examination of specimens. Evaluation of these names must await a complete revision of the species of *Papuina*. In the meantime, they may be used subgenerically. *P. periwonensis* seems best included in *Pinnadena* (Type *Helix lombei* Pfeiffer). From the *lombei* series it may be distinguished by the very sharp keel on the periphery.

Gyropena nissani n. sp.

Fig. 1*e–g*

Shell small, discoidal, umbilicate. Whorls three and a half including a spirally striate protoconch of one and a half whorls. Sculpture on postembryonic whorls consisting of fine raised radial riblets, about 85 on body whorl. Interstices with fine growth lines and fine spirals. Spire very slightly elevated. Periphery rounded. Suture impressed. Aperture rather wide, sub-lunate, unarmed. Umbilicus deep, perspective, about one third the greatest diameter.

Major diameter 2.04 mm.; height .92 mm.; diameter of umbilicus 0.6 mm.

Holotype (M. F. 2513) in Dominion Museum, New Zealand.

Locality: Near Tangalan Plantation, Nissan Island, northern Solomons, in forest litter, R. K. Dell, June, 1944.

The only two members of the family Charopidae hitherto recorded from the Solomons are *Endodonta* (*Charopa*) *solomonensis* Clapp from Ugi, and *Foxidonta stevensoni* Clench from Malaita. *Foxidonta* is a peculiarly turreted shell, large for the family, and doubtfully belonging to it. *Charopa solomonensis* Clapp seems very similar to the New Zealand species around *C. anguiculus* (Reeve). It has a smooth protoconch. Jutting (1951: 28) has described *Charopa* (*Discachoropa*) *microdiscus* from Java and South Celebes, with fine radial riblets on the protoconch. The type of *Discocharopa* (*D. exquisita* Iredale) from the Kermadecs, has a smooth protoconch. It is not unusual for the fine radials on the protoconch to be worn off leaving an apparently smooth protoconch and *solomonensis* and *microdiscus* may both for the present be classed under *Discocharopa*. The former is somewhat larger than the other species ascribed to this genus and close examination of actual specimens may well show other points of difference. *Gyropena nissani* n. sp. has a protoconch with well-marked spirals, a very flattened spire, and an impressed suture. In some respects it recalls the New Zealand charopid genus *Mocella*. However, the general facies and the impressed suture agree with the description and figure of Iredale's *Gyropena* from Lord Howe Island.

The importance of these scattered charopids from the Solomons and the Greater Sunda Islands is that they probably represent relics on the migration route through which the charopid faunas of southern Australia, New Caledonia, Lord Howe, Norfolk, the Kermadecs, and New Zealand were derived.

TABLE 3

SHELL MEASUREMENTS OF *Partula* (*Melanesica*) *carteriensis* (Q. AND G.)
(Measurements in Millimeters)

SPECIMEN	NUMBER OF WHORLS	HEIGHT	DIAMETER	HEIGHT OF APERTURE	WIDTH OF APERTURE
Nissan	4½	17.8	9.8	9.0	5.6
Nissan	4½	17.5	8.9	9.0	6.2
Nissan	4½	17.3	9.3	9.2	6.2
P. carteriensis (*fide Pilsbry*)	5	17.5	8.5	9.0	6.0
P. carteriensis (*fide Pilsbry*)	4½	16.0	8.7	8.7	6.0

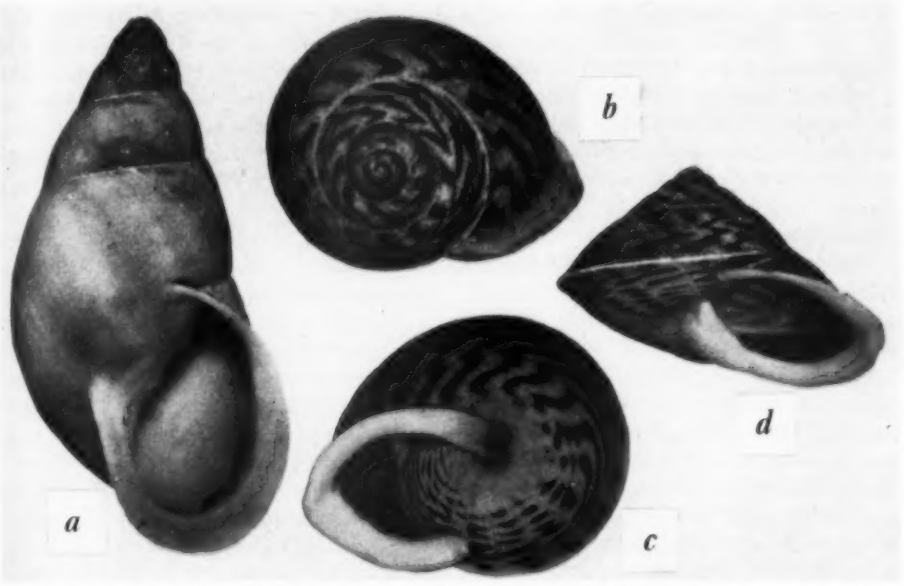

FIG. 2. *a*, Shell of *Partula* (*Melanesica*) cf. *carteriensis* (Q. and G.) (Nissan Island, 17.8 × 9.8 mm.). *b–d*, Apical basal, and frontal aspects of the shell of *Papuina* (*Pinnadena*) *periwonensis* n. sp. (holotype, 28.0 × 19.1 mm.).

Partula (Melanesica) cf. carteriensis
(Q. and G., 1832)
Fig. 2*a*

A species of *Partula* was comparatively common on the island living on vegetation. The collection contains three specimens. They are close to *P. carteriensis* (Q. and G.) as described and figured by Pilsbry (1909: 298, pl. 36, figs. 15, 16) and the geographical position of Nissan in relation to New Ireland makes it very probable that they are closely related if not identical. The spiral sculpture is very fine as described for *P. carteriensis* (Q. and G.). Table 3 gives shell measurements of Pilsbry's specimens and three from Nissan. The systematics of the group in the Solomon Islands is so uncertain that a figure is given of a Nissan Island specimen. The tooth on the parietal lip is absent in the other specimens.

Opeas gracilis Hutton, 1854

A number of specimens were collected under rotten wood near the lagoon at Tangalan Plantation. This species is a tropical cosmopolite and has been recorded from many of the islands of the Solomon group.

DISCUSSION

Thirteen species of land snails are herein recorded from this small island and it is highly probable that other forms will be collected in the future. It is, however, unlikely that any large species were missed. The relationships of this fauna are, as might be expected, with both the Bismarck Archipelago and with the other Solomon Islands. Four of the species appear to be endemic to the island but for three of these (*Orpiella nissani*, *Gyropena nissani* and *Paludinella solomonensis*) this is probably an apparent, rather than a true endemism. So little is known of the molluscan fauna of the northern Solomons, especially the smaller forms, that little value can as yet come from such comparisons. It is more likely that *Papuina periwonensis* is truly endemic although again it could quite easily

occur also in northern Bougainville or Buka.

Of the nine non-endemic forms, one, *Opeas gracile*, is a cosmopolitan tropical form which has probably attained its present wide distribution through the assistance of man. Five species, *Omphalotropis nebulosa*, *Leptopoma vitreum*, *Pseudocyclotus levis*, *Eustomopsis eustoma*, and *Pupina keraudreni*, occur both in the Bismarck Archipelago and throughout the Solomons. *Partula carteriensis* is known elsewhere only from New Ireland. *Syncera nitida guamensis* occurs in the Carolines and *Sturanya modesta* has a fairly wide distribution throughout the Solomons and New Hebrides and has been recorded from Samoa. The two best represented elements in the fauna therefore are (a) the four endemic forms, and (b) the five species that range from the Bismarck Archipelago to the southern Solomons. The latter group must consist of species that either have been in the area for a long period of time or have efficient methods of dispersal. Since such geographical variation as has been observed in members of the group in this area is very slight or incipient, it seems most unlikely that these forms have been long established on Nissan or the other islands of the Solomons. We have, then, the situation that the two groups of species best represented on Nissan consist of one that has been present for a sufficiently long period to acquire strong differentiating characters and another that has become widely spread in the Solomons and colonized Nissan en route. That this movement has probably been mainly from the northwest to the southeast is shown by the wide distribution of such forms as *Leptopoma*, *Pseudocyclotus* and chloritid mollusks in the Austro-Malayan region.

The waifs and strays of the Nissan fauna are such as one would expect in an oceanic island, and three of these, *Paludinella*, *Syncera* and *Opeas*, are forms that appear to be confined to coastal areas.

Nissan is an elevated and probably tilted coral atoll, some 15 miles in diameter. Most of the surface of the island is covered by dense forest apart from two quite considerable patches of coconut plantations. Situated between Buka in the northern Solomons and New Ireland it is about 30 miles from Buka and 70 miles from New Ireland. However, it is more closely connected with New Ireland by the small island group of Feni, which is about halfway between. Ocean depths between Nissan and New Ireland are at least over 2,000 fathoms, and it is most unlikely that the two areas have been joined in the recent past by a fall in sea level. The land Mollusca of Nissan (apart from the endemic species which may be older in origin) must, therefore, have been derived by transoceanic migration. Very little is known of the methods used for such transoceanic dispersal by land snails although there has been a great deal of conjecture, especially in the literature of the latter part of the nineteenth century. What does seem very apparent is that some land snails do cross ocean barriers. At least it is as logical to assume that they do, as to postulate a land bridge in the face of strong biological and geological evidence to the contrary. In an attempt to derive some elements of the Solomon Island land snail fauna from the Bismarck Archipelago, the strait between New Ireland and Nissan presents the first and probably the widest oceanic barrier. The land snails present on Nissan show that some species have crossed this gap comparatively recently and that presumably they could also spread further south.

These remarks would apply to the *Eustomopsis*, *Omphalotropis*, *Leptopoma*, *Pseudocyclotus* and *Pupina*. *Partula carteriensis* has apparently crossed the strait but has not, so far as is known, extended its range further south. Three of these forms, *Leptopoma*, *Pseudocyclotus* and *Partula* are arboreal in habit while the other three are terrestrial, so there is apparently no advantage in motility as regards type of habitat.

When the fauna of Nissan is considered in relationship to the zoogeography of the Solomon group, some very distinctive elements are seen to be missing. No species of *Placostylus* extends as far north, and such characteristic genera as *Trochomorpha* and *Dendrotrochus* are not represented.

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A Study of the Structure, Affinities, and Distribution of *Tetraplatia volitans* Busch (Coelenterata: Hydrozoa: Pteromedusae)[1]

CADET HAND[2]

INTRODUCTION

THE HYDROZOA include a large number of curious animals, not the least unusual of which are the tetraplatians. Two species of *Tetraplatia* have been described, *T. volitans* Busch (1851) and *T. chuni* Carlgren (1909). These hydromedusans are so highly modified in form that their true nature is seldom recognized when they are first encountered.

Tetraplatians are elongate (to 9.5 mm.) medusans of bipyramidal form with ciliated outer surfaces. The mouth lies at one extremity whereas the other end represents the aboral tip of the bell. In cross section the aboral region may be nearly cylindrical, quadrangular or octagonal while a cross section of the manubrium (oral end) may be circular to quadrangular. A constriction occurs near the middle of the body. In *Tetraplatia volitans* (Fig. 1) this constriction is bridged by flying-buttresses connecting the angular corners of the manubrium to the four major angles of the bell above the groove. These buttresses are absent in *T. chuni*. In the constriction and between the buttresses in *T. volitans*, and in a corresponding position in *T. chuni*, arise four, bilobed, swimming appendages, the wings or lappets. Each lobe of each lappet has a statocyst. These lappets have a solid endodermal core (see Fig. 2). At the free extremity of the lappets there is a thin sheet of ectoderm which is interpreted as the velum; this velar structure may be continuous around the body in the constriction although not all specimens seem to show this. The lappets commonly have been called bilobed; however, at their free end 8 or 10 small velar projections can be found, four or five to each lobe. These projections are the result of at least three bifurcations of the supporting structure within the lappet, the first producing the bilobed appearance of the contracted lappet and the latter ones leading out to the terminal velar projections of the lappets (Fig. 3). The surface of tetraplatians is marked by ridges, which are tracts of nematocysts; commonly the bell has eight tracts, four in the axes of the buttresses and four in the axes of the lappets, although those in the lappet axes may be absent. The manubrium never has more than four rows of nematocysts and these always are in the buttress axes.

Internally tetraplatians consist of a large, essentially quadrangular, gastrovascular cavity. The coelenteron extends into the buttresses from both the oral and aboral halves of the body. It has been reported that at the midpoint of the buttresses there may be a

[1] Contribution from the Scripps Institution of Oceanography, New Series No. 769. Manuscript received November 22, 1954.

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mesogleal septum separating the oral coelenteric pouch from the aboral (Carlgren, 1909) or that the passageway may be blocked by an endodermal plug (Dantan, 1925), although neither of these structures is necessarily present.

There are four gonads in the tetraplatians, each with an oral and an aboral bilobed portion. The gonads originate below the velum in the axes of the buttresses and project inside the animal, largely filling the coelenteron when the animal is mature. The sexes are separate.

In summary, the tetraplatians are considered to be tentacleless medusans whose body is divisible into aboral and oral halves, separated by a line of tissue lying in the bottom of a constriction, this tissue representing the margin of the bell and the velum. The subumbrellar part of the animal is highly reduced and consists of only the manubrium and the tissues on the adoral surfaces of the lappets.

REVIEW OF RECORDED KNOWLEDGE

Tetraplatia volitans was first described by Busch (1851), presumably from a single specimen, taken at Málaga, Spain, in the Mediterranean Sea. He apparently observed the animal alive for a period of 2 days, and although he did not express an opinion on the nature or affinities of the animal, his description was good enough to enable subsequent authors to recognize it. Shortly after Busch's discovery, Krohn (1853) reported the finding of four specimens at Messina, Sicily. Twelve years later, having obtained no more specimens, Krohn (1865) published detailed observations on the four specimens he had obtained and suggested they must be young forms of some medusa (scyphozoan). Leuckart (1866), in considering the work of Krohn, suggested that *Tetraplatia* might be related to the medusan group of aeginids (now narcomedusans), and subsequently Claus (1878) in a very fine study established quite definitely the hydromedusan nature of the animal although at the same time he seemed to feel that it was half medusan and half polypoidal and thus intermediate between polyps and medusae. Claus, however, used the name *Tetrapteron* (*Tetraplatia*) *volitans* for this species, and thereby created the first of the two recognized synonyms of *Tetraplatia volitans*, the second being that of Fewkes (1883) who used the name *Tetraptera volitans*. Haeckel (1879) in his "System der Medusen" suggested *Tetraplatia* might be a larval narcomedusan or that it might be intermediate between the hydroid polyps and the craspedote medusae. Fewkes (1883) in a brief note suggested that this curious animal might be best assigned a position between the craspedote medusae and the ctenophores. Viguier (1890), in an elaborate study of *Tetraplatia*, discussed the similarities of this animal to the trachymedusans, hydromedusans, larval actinians, scyphomedusans and ctenophores and seems to favor their relationship to the trachyline medusae. Perhaps the most careful and complete study of the tetraplatians is that of Carlgren (1909) based upon specimens from the Deutsche Tiefsee Expedition and also on specimens from Messina. From a single specimen from the west coast of Africa he described the species *T. chuni*, and after elaborate morphological and histological study of it and of specimens of *T. volitans*, Carlgren proposed a new order, the Pteromedusae, for *Tetraplatia*. This order represented a third group of trachyline medusae of equal rank to the Trachymedusae and Narcomedusae. Subsequent to Carlgren's study Krumbach (1924) decided that the tetraplatians were really larval animals in spite of their possession of well developed gonads, and placed them among the Scyphomedusae. In 1925 Dantan published a detailed study of *Tetraplatia volitans*. He disagreed with Carlgren's study on a number of points, perhaps the most important of which concerned the origin of the statocysts. Dantan maintained that these balance organs were of ectodermal origin, as opposed to the endodermal origin proposed by Carlgren, and after much discussion placed *Tetraplatia* among the Anthomedusae. Weill

(1934) in his study of the nematocysts of the coelenterates concluded from the figures of Viguier (1890) that *Tetraplatia* has a monocnidom of atrichous isorhizas and as such must be assigned to the Narcomedusae. Weill's opinion seems to have been completely accepted by Hyman (1940), and the trachyline affinities of this animal have been quite generally accepted among those who have actually worked with the animal except for Dantan (1925) and Komai (1939). Komai concluded that *Tetraplatia* is a primitive scyphozoan, close to the Cubomedusae and Stauromedusae.

The distribution of *Tetraplatia*, with the data included in the present report, is nearly world wide. The first *Tetraplatia* was taken in the Mediterranean Sea (Busch, 1851) and the next several reports of the animal were also from the Mediterranean concerning specimens taken at Messina. In 1885 Viguier reported finding specimens in the Bay of Algiers and his report of 1890 concerns the finding of these animals at that locality for five successive winters through a seasonal period from the end of December to the last of March and early April. Viguier was the first person to find *Tetraplatia* in large numbers and reported taking 200 specimens in a single net haul. Rose (1926) reported a single specimen from the Bay of Algiers. Carlgren (1909) extended the distribution of *T. volitans* to the neighborhood of the Chagos Islands in the Indian Ocean (4°5.8′ S., 73°24.8′ E.; 2°38.7′ S., 65°59.2′ E.) and also reported the single known specimen of *T. chuni* from the beginning of the Benguela current off the west coast of Africa at 36°23.4′ S., 17°38.1′ E. Dantan (1927) in a brief summary of the distribution of *T. volitans* reported it from the type locality of *T. chuni* but this was apparently an error. The next extension of known range occurred when Leloup (1935) reported the discovery of eight specimens of *T. volitans* from seven net hauls of the "Meteor" samples from the Atlantic (stations 41, 166, 183, 184, 216, 234, 278). These specimens ranged from 17° N. to 29° S. in the eastern Atlantic and

FIG. 1. *Tetraplatia volitans*. The upper specimen shows a widely flaring mouth and presumably was in the process of engulfing food at the time of fixation. (Carbon drawings by Mrs. Lois Stone, Department of Zoology, University of California, Berkeley.)

from about 23° to 30° S. in the western Atlantic (east and south from Rio de Janeiro, Brazil). Komai (1939) reported this animal from the Pacific for the first time. His report concerned four specimens taken in May at Susaki, Japan. Carlgren (personal communication) has informed me that he also has specimens from the western Pacific collected

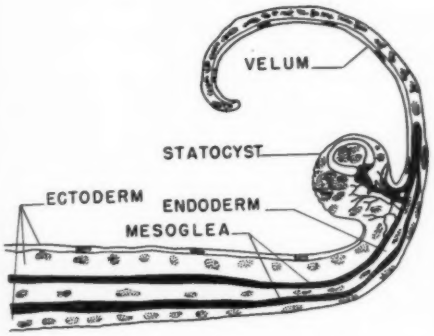

FIG. 2. Section through a lappet and statocyst, oral surface uppermost.

by the Dana expedition. The present report concerns the occurrence of *T. volitans* in the eastern Pacific. A total of 211 specimens has been found in 76 different net hauls from 44° N. to 5° S. and as far west as 131° W. The most northerly specimen was collected at 44° 12′ N., 128° 37′ W.; the most southerly at 5° 04′ S., 95° 56′ W. and the most westerly at 39° 38′ N., 131° 36′ W. Of the total specimens from the Pacific Ocean 167 were collected during the course of routine sampling by the Scripps Institution of Oceanography as part of the California Cooperative Sardine Research Program and also on its expedition "Shellback" to the eastern tropical Pacific. The remaining specimens (44) were collected in Monterey Bay, California, by personnel of Hopkins Marine Station during the course of their work on NC–ONR# 25127. Figure 4 shows the areas from which the specimens from the eastern Pacific were collected whereas Figure 5 indicates the world wide nature of the distribution of *T. volitans*. No specimens have been reported from the Arctic or Antarctic regions, nor as yet from most of the southern and western Pacific.

The early workers on *Tetraplatia* commented but little upon its way of life. All the early specimens seem to have been taken in superficial net hauls and usually at night. Viguier (1890) thought they occurred "en petites troupes" and that they were the pelagic phase of a fixed or benthic animal. He points out that he did not find these animals associated with the truly pelagic (oceanic) forms. Carlgren (1909) was of the opinion that the tetraplatians were holoplanktonic. Dantan (1925), however, basing his conclusions on his observations of living animals, their movements and behavior, and on the spotty occurrence of these animals believed that they occur only accidentally in the plankton. He thought that they were not truly pelagic and that they lived near the bottom in rocky areas since net samples near sandy and muddy bottoms did not contain them. Dantan also disagreed with Viguier to the extent that when he (Dantan) found *Tetraplatia* it was in typical plankton assemblages. Leloup (1935) has taken an al-

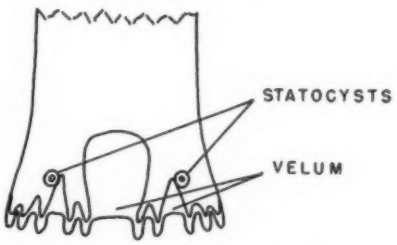

FIG. 3. Oral view of an expanded and flattened lappet.

together different point of view on the mode of life of this animal, and one to which I subscribe as will be seen in the observations and discussions to follow. He points out that the animals seem to be taken either in deep hauls during the day or in surface hauls during the night and suggests the animal must undergo a diurnal migration, coming to the

surface during the night. He also notes that whereas Dantan thought *Tetraplatia* must live near the bottom many specimens have been taken at distances several thousands of meters above the bottom.

As long as *Tetraplatia* was known from only the Mediterranean Sea it was thought of as an animal of rather regular seasonal occurrence. Viguier (1890) found it to occur from December to April and Carlgren (1909) reports that he was informed by letter that the season at Messina was from January to the end of July. The "Valdivia" material from the Indian Ocean was collected in February and March, while the "Meteor" specimens from the Atlantic were collected in March, April, July, October, and November. Carlgren's specimen of *T. chuni* was collected in November. Although the Mediterranean specimens still seem to appear only seasonally this is not true of the Atlantic material, which would appear to be present in all seasons. In the Pacific *Tetraplatia* has been found in samples taken in every month except January and presumably is present at all times of the year. Thus the problem remains of the apparent seasonality of occurrence in the Mediterranean and the apparent lack of seasonality in the Atlantic and Pacific, although samples from the latter two areas are too scanty to rule out seasonal periods of maximal and minimal abundances.

Most of the reports on *Tetraplatia* have dealt with it as a morphologic and systematic curiosity and very little is known of it as a living animal, except for the early studies of Busch, Krohn and Viguier. Dantan (1925) seems to have been the only recent worker to have studied it alive. The foregoing studies, however, give much information on its mode of swimming and the curious writhing movements which it undergoes, and the numerous excellent figures of Viguier (1890) show quite adequately the many shapes this medusa may assume. One interesting fact relative to the living *Tetraplatia* was the report by Viguier (1885) that the refringent bodies (statocysts) were spontaneously luminescent and that they gave off a blue light. In his 1890 report, however, Viguier, after repeatedly seeking to confirm his earlier observation on the luminescence of the statocysts and having failed, suggests that what he observed may have been the result of the beginnings of the decomposition of the statocysts.

OBSERVATIONS ON PACIFIC MATERIAL

The 211 specimens of *Tetraplatia* which have been taken in the eastern Pacific have all been identified as *T. volitans* Busch. These specimens have an average size of 4.2 by 1.6 mm. and a range of from 1.0 by 0.6 mm. to 9.5 by 2.0 mm. The ratio of length to width approaches 1:1 in small contracted specimens although it is about 2:1 in most specimens less than 2.5 mm. long. Specimens of 3 mm. length and longer commonly have a length-

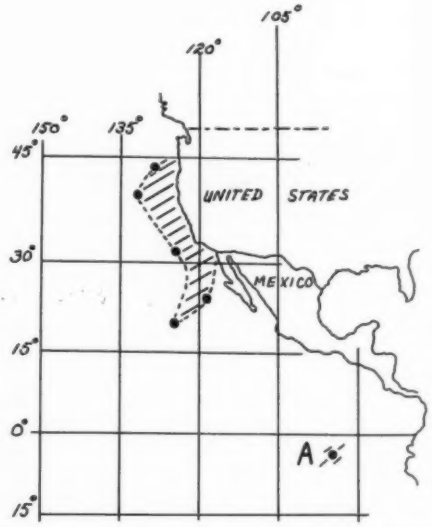

FIG. 4. Distribution of *Tetraplatia* in the eastern Pacific. Shaded area enclosed by dashed line indicates area from which *Tetraplatia* has been collected. The dot at A indicates the position from which the most southerly specimen was obtained, the dots on the dashed line represent the positions of collection of specimens which delimit the area within which most of the material was collected.

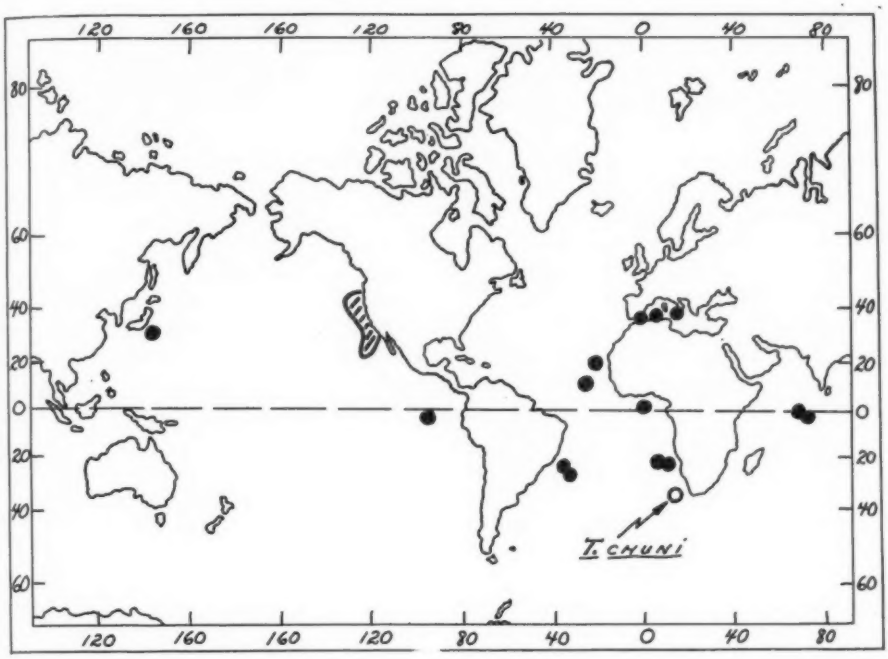

FIG. 5. Worldwide distribution of *Tetraplatia*. Dots and the shaded area in the northeastern Pacific represent localities which have produced *T. volitans*. The open circle is the locality from which *T. chuni* was collected.

to-width ratio of 3:1 with the very slenderest specimens having nearly a 5:1 ratio.

A number of specimens (12) were stained with borax carmine or rose bengal and subsequently cleared. One of the very obvious features of specimens so handled was the absence of the septum in the buttresses. Approximately at the midpoint of the buttresses there may be a slight thickening of the tissues, but in most specimens there was an open endodermal passageway from the oral to aboral coelenteron. In some of the buttresses this passageway seems to be closed off by the endodermal lining, although in six specimens which were prepared as serial sections no blockage was discovered. The passageway is not well formed, however, and consists of an irregular space lined by endoderm and at points along its course the endoderm cells nearly close it off. No sign whatsoever was seen of a mesogleal septum. Komai (1939) also reports the passageway as open, but Dantan and Carlgren, nonetheless, have reported this septum in material they have examined. It would seem therefore that the buttress canals may be closed by a mesogleal septum, an endodermal plug or, more commonly, contain an irregular endodermally lined canal. No special function can be assigned to the buttresses and their contained structures other than the obvious role the endodermal lining must play in the nutrition of the animal.

The presence of these buttresses is the character which most obviously separates *Tetraplatia volitans* from *T. chuni* which lacks these structures. It was therefore of great interest to discover that these structures are not constant and that on some specimens only two buttresses were present. Four spec-

imens were found which represented variations from the normal plan of four buttresses per animal. Figure 6*a* and *b* illustrate the first of these anomalies in which a buttress is nearly separated into halves, the halves apparently connected by only a thin piece of ectoderm. All other buttresses on this specimen were normal. A second anomalous specimen possessed only two buttresses; these were adjacent to one another and were normal in all respects. This specimen, however, possessed only three swimming plates and only the two buttresses just mentioned. Figure 6*c* and *d* illustrates this specimen. This specimen was triangular in cross-section except for the buttress missing from the side shown in Figure 6*d*. A third irregular specimen was one which possessed the normal four lappets but possessed only three buttresses, one being completely missing. The last anomaly was a specimen which also possessed four lappets, but only two buttresses, these being located 180° apart. This specimen is illustrated in Figure 6*e* and *f*.

Carlgren's *T. chuni* seems to be very little different from *T. volitans*, the major differences being the absence of the buttresses and the narrower lappets of his species as compared with *T. volitans*. In *T. volitans* the lappets, in general, are about as broad as the space between any two adjacent lappets, while in *T. chuni* the space between the lappets is about twice as wide as the lappets themselves. Our knowledge of *T. chuni* is based on a single specimen, 8 mm. long by 4 mm. wide, which by the standards of *T. volitans* is an unusually large, robust specimen. Careful measurements on the more robust specimens of *T. volitans* from the Pacific have indicated that the width relationships of the lappets to the space between lappets approaches the relationship of these measurements on *T. chuni*, but no specimen has been found whose lappets are quite as narrow as Carlgren described for his species. Also no specimen of *T. volitans* has been found which was as inflated as *T. chuni* and this in itself may account for the differences observed. In *T. volitans*, as the specimens become greater in diameter (due largely to their state of expansion and contraction at the time of fixation), the width of the lappets becomes less as compared to the space between. It may be, therefore, that the presumed difference in relative widths of lappets between the two species is an artifact of preservation. As far as the difference in presence and absence of the buttresses between these two species is concerned it now is strongly suggested that this difference also may be an artifact, due in this case to a failure in the development of the buttresses. I do not choose, at this time, to

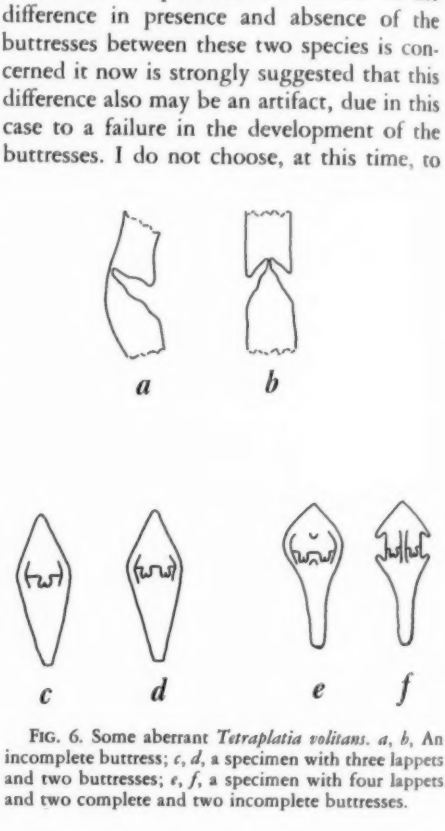

FIG. 6. Some aberrant *Tetraplatia volitans*. *a*, *b*, An incomplete buttress; *c*, *d*, a specimen with three lappets and two buttresses; *e*, *f*, a specimen with four lappets and two complete and two incomplete buttresses.

synonomize *T. chuni* with *T. volitans*, but such an act does not seem unwarranted. Another matter, which bears on this problem, concerns the geographic position from which *T. chuni* was collected (see Fig. 5). Carlgren's specimen came from the beginning of the Benguela current off the west coast of the tip of Africa, while in the same current, some 14° to the

north, Leloup obtained three specimens of *T. volitans* from the "Meteor" samples. From these facts it would not seem unreasonable to suggest again that *T. chuni* may be an aberrant specimen of *T. volitans*.

Among the many plankton samples examined I had the good fortune to discover specimens of *Tetraplatia* in a group of samples from horizontal, closing-net, tows taken in a vertical series. Four series of samples were taken at a single station (approximate position, 33° N., 117° W.) on the 4th and 5th of March, 1953. These consisted of two night series (2000–0330 hrs., 0400–0515 hrs. P.S.T.; the first series of 12 separate tows and the second series of only four separate tows) and two daylight series (1620–1820 hrs., 0615–1100 hrs. P.S.T.; the first of five tows and the second 11 tows). These tows were made with a net 1 meter in diameter, towed for 10 minutes. Table 1 indicates the length of wire used in each of the tows and the numbers of *Tetraplatia volitans* taken.

From the table it can seen that *Tetraplatia* was common in the first night series of samples and was absent from all others. These results agree very well with the suggestion of Leloup (1935) that *Tetraplatia* undergoes a diurnal vertical migration, approaching the surface only at night, except for the absence of specimens from the second night series. Sunrise, on the days when these samples were taken, was at approximately 0625 P.S.T. and during the time when the second series of night samples were taken the moon was slightly more than half illuminated and was nearly overhead. In the first night series no specimens were taken at the surface or at 10 meters depth while two and seven specimens were taken at 25 and 40 meters, respectively, so perhaps *Tetraplatia* was really absent from only the latter two hauls of the second night series. Also, since these latter two hauls were taken one hour and 45 minutes and one hour and 15 minutes, respectively before sunrise, it may well be that the *Tetraplatia* had already begun their descent toward their daytime environment.

TABLE 1

THE NUMBER OF *Tetraplatia volitans* TAKEN IN A VERTICAL SERIES OF HORIZONTAL CLOSING-NET TOWS MARCH 4 AND 5, 1953

LENGTH OF WIRE OUT (METERS)	NIGHT SERIES		DAYLIGHT SERIES	
	No. 1	No. 2	No. 1	No. 2
Surface	0	0	0	0
10	0	0	0	0
25	2	0	0	0
40	7	0	0	0
60	4	**	**	0
80	3	**	**	0
100	2	**	*	0
150	0	**	**	0
200	1	**	**	*
300	0	**	**	*
400	..	**	**	*

* Net did not function properly.
** No sample taken.

Excluding the 19 specimens collected in the series of hauls just reported, a total of 134 specimens has been recovered from 45 net hauls and of the 45 net hauls, only 12 were made during daylight hours. Of these 12 daylight samples, all but one were tows during which the net fished at depths greater than 300 meters, the exception being a tow whose greatest depth fished was approximately 70 meters. As compared to this single daylight haul which captured a single specimen, 15 night net hauls whose greatest depth reached was 70 meters produced a total of 19 specimens. The 11 remaining daylight tows which fished to depths greater than 300 meters produced a total of 79 specimens (1, 1, 1, 1, 2, 3, 7, 11, 16, 17 and 19 specimens per haul, respectively). With the exception of the haul which produced 16 specimens, these hauls were tows which fished from about 500 meters to 1,022 meters. The sample containing 16 specimens was a closing net tow taken at a depth of about 300 meters at 1455 P.S.T. From the data presented above it now seems to be apparent that *Tetraplatia volitans* is a

TABLE 2

THE NUMBER OF *Tetraplatia volitans* TAKEN IN A VERTICAL SERIES OF HORIZONTAL CLOSING-NET TOWS JUNE 12 AND 13, 1952

NIGHT SERIES			DAYLIGHT SERIES		
Wire Out (Meters)	Time	Number of Specimens	Wire Out (Meters)	Time	Number of Specimens
10	2152	0	Surface	0913	0
4	2219	0	10	0935	0
25	2253	0	25	0955	0
40	2400	0	40	1030	0
60	0029	1	80	1130	0
100	0135	1	100	1155	0
150	0205	1	150	1223	0
200	0243	1	200	1300	0
300	0325	1	300*	1340	0
400	0410	4	300	1420	0
			400	1455	16

* Net did not close.

form which undergoes a diurnal vertical migration, approaching the surface at night and returning with the advent of sunrise to rather great depths. It should be pointed out that most of the samples of *Tetraplatia* which have been obtained were collected at positions where the depth to the bottom was greater than 1,000 meters and in many cases in water several thousand meters deep.

The sample mentioned above containing 16 specimens was one of a group of horizontal tows taken in a vertical series on June 12 and 13, 1952 at 33° 28.5′ N. by 117° 46.7′ W. *Tetraplatia volitans* was taken in seven of the 21 tows of this series (six tows of the night series and one of the day series). The results from this series of samples are shown in Table 2.

It will be noticed in this vertical series that by no means all of the specimens were taken near the surface at night, but instead they seem to be fairly evenly distributed over depths of about 40 to 300 meters (assuming a wire angle on these tows of about 45°). In the vertical series reported earlier in this study the center of the population, at night, seemed to have been in the neighborhood of 40 meters. It therefore is apparent that although some tetraplatians undergo a marked vertical migration this is not necessarily the case, although these animals, almost without exception, descend to or stay at depths of 250 meters or more in the daytime.

Little information is available concerning the depths to which *Tetraplatia* may descend. Specimens have been recovered from samples in which the net fished from about 1,000 meters to the surface in the Pacific, while some of the "Meteor" specimens were taken in net hauls to depths of 900 meters and the "Valdivia" specimens to depths as great as 2,500 meters. However, since these net hauls were not closing-net tows, little but speculative results can be gleaned from them and no exact information is available concerning the lower limits of the vertical distribution of *Tetraplatia*. The 44 specimens from Monterey Bay add a little information along this line since it appears from the 11 tows which captured *Tetraplatia* that in general the deeper the tow the more specimens were captured. These tows were continuous from the depth

recorded to the surface and the number of specimens captured and depths reached were as follows:

Depth	*Number of Specimens*
510	1
620	2
775	1
846	3
870	2
890	2
960	4 (½ of sample only)
995	2
1,005	7
1,022	19
1,065	1

Tetraplatia, like most medusans, seems to be a rather omnivorous carnivore. Dantan (1925) seems to be the only other worker who has noted any of the food items of these animals and he found only a few specimens containing any identifiable food substances. He found the remains of an annelid larva, parts of a crustacean and a small chaetognath. In the specimens from the Pacific, also, only a few individuals have been noted containing identifiable food items. These included an immature euphausiid, a chaetognath and three copepods. Two specimens of *Tetraplatia* were noted whose mouths were widely flared,

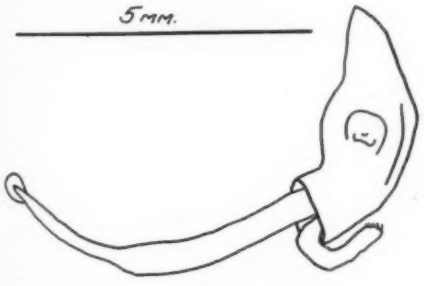

FIG. 7. A sketch of *Tetraplatia volitans* which had captured a chaetognath.

as if they had been attached to some rather large animal at the time of capture. An organism such as *Tetraplatia* can readily ingest another animal of its own bulk which was nearly the situation with the specimen found ingesting the chaetognath. This individual with the partly swallowed arrow worm is sketched in Figure 7.

Nematocysts

Recently considerable attention has been turned toward the nematocysts of coelenterates. Weill (1934) used these structures to show phylogenetic relationships and Papenfuss (1936) and Hand (1954) have shown that these characters may be useful in the identification and separation of species. Russell (1938, p. 162) concurs with Weill that the study of nematocysts "may be of value in showing phylogenetic relationships," but questions their value as specific characters. In his elaborate study of 1934, Weill considered the nematocysts and affinities of *Tetraplatia volitans* and concluded that these animals were narcomedusans. He did not personally observe the nematocysts of this species but instead based his conclusions on the descriptions and figures of Viguier (1890).

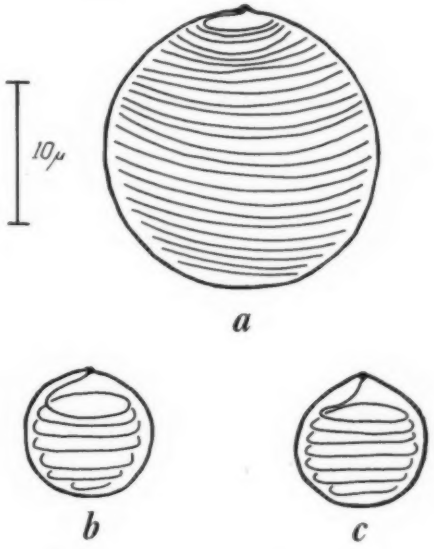

FIG. 8. Nematocysts of *Tetraplatia volitans: a*, a large atrich; *b* and *c*, small atrichs.

Contrary to Viguier's opinion Weill felt that the variability in the size of the nematocyst capsules was insufficient to recognize more than one category—atrichs. In the present state of our knowledge the Narcomedusae, the group to which *Tetraplatia* was assigned by Weill, may be stated to have a monocnidom of atrichous isorhizas (atrichs).

I have examined twelve specimens of *Tetraplatia volitans* to determine the cnidom of this species as it exists in the eastern Pacific. Nematocysts are rare or absent from most of the body and are largely confined to the nematocyst tracts, although near the distal end of the manubrium the tracts become diffuse and nematocysts are generally distributed over this area. Only one type of nematocyst has been found in the tissues of *Tetraplatia*, this being an atrichous isorhiza, although two very obvious size categories are present. The smaller capsules appear to contain a coarser thread than the larger, and the thread in the larger capsule has many more coils than the smaller. Figure 8 illustrates the appearance of these atrichs. The capsules are all very nearly spherical, with some tendency to develop a low conical shape toward the opercular region, at least in the smaller ones. The large atrichs are restricted to the manubrium in their occurrence while the smaller occur throughout the nematocyst tracts. Dantan (1925) indicated that he too found a large and small type of nematocyst, although he gave very little indication of their structure. The sizes of the two categories of atrichs were as follows:

Small—8–12 μ diameter
Large—18–22 μ diameter

Komai (1939) also found two sizes of nematocyst, one 20 μ in diameter, the other 8 μ. He did not indicate what type nematocyst these were but his sizes agree well with what I have found.

Statocysts

Both Viguier (1890) and Dantan (1925), in their illustrations of whole *Tetraplatia*, have indicated the positions which the statocysts occupy. Carlgren (1909) has also described their location although he did not indicate their positions by figures. These writers seem to agree that the statocysts are located on the oral sides of the lappets, one in the middle of each of the two major lobes of the lappets at the junction of the velum and the lappet proper. Dantan had some difficulty in locating the statocysts, due to the more or less contracted and coiled-up condition of the flaps, and had to rely on sections to locate them. A number of the *Tetraplatia* from the Pacific have been examined in which the lappets were fully extended and in excellent states of preservation. As was remarked earlier, the term "bilobed" as applied to the lappets, is something of a misnomer since the lappets actually are divisible into at least eight terminal lobes. Moreover, the statocysts are not located at the midpoints of the two halves of the lappets, but are to be found just to the outer side of the second bifurcation of the supporting core of the lappets, as illustrated in Figure 3. The statocysts occur in a raised knob of tissue, and in sections it appears that the lithocytes have been derived from the endoderm. Figure 2 illustrates a section of a lappet through a statocyst.

In considering the structure of the lappets one feature appeared which was of considerable interest. This is the morphology of the nuclei of the velar and endodermal cells. The nuclei of the velum show a remarkable flattened and multilobed polymorphic structure, which is reminiscent of the nuclei of polymorphonuclear leucocytes. This is also true of some of the endodermal nuclei of the lappets which show a gradual transition from ovoid nuclei near the lappet base to the flattened, polymorphic type in the distal lappet endoderm. Dantan (1925) also noted these curious nuclei and Komai (1939) concluded that all of the cells possessing these polymorphic nuclei were endodermal.

The fully extended lappets of three specimens were constructed as is shown in Figure

3; that is, with the third bifurcation of the core of the lappet being wider on the outer than the inner side and with this lobe divided into two equal parts at its very tip. These lappets thus have ten terminal velar lobes. The fully extended lappets of three othe specimens possessed unequal third bifurcar tions, but did not show the terminal division of the outermost lobe. The sizes of the specimens (3.2, 4.8, 5.0 mm.) which possessed ten velar projections were not significantly different from those which possessed only eight (2.4, 5.0, 5.2 mm.), and although one could easily assume that this variation in numbers of velar lobes is an age-correlated phenomenon it is not demonstrable as such from the data at hand. Attempts to determine the number of terminal velar lobes present on very small specimens (1 to 2 mm.) met with very desultory results. Most of these little animals possessed very tightly rolled lappets, and unrolling them is nearly impossible. On two specimens, however, it was possible to count eight terminal lobes on at least one lappet of each. The appearance of the division of the lateral terminal lobes, changing the number from eight to ten, may well be one which occurs fairly late in the development of these animals or may be a character which expresses itself in varying degrees.

DISCUSSION

Since Komai (1939) has so strongly espoused the contention that *Tetraplatia* is a scyphozoan, considerable thought has been applied to test the basis for his conclusions. Komai has used the "octamerous arrangement of organs" and the "entodermal origin of the gonad" as features of a scyphozoan nature and has compared the lappets to the arms of stauromedusans. He makes a special point of identifying the structures usually considered as the velum with the tentacles of the Stauromedusae and he points out that *Tetraplatia* also resembles the cubomedusans in its quadratic structure. Komai (1939, p. 248) finally concluded that ". . . *Tetraplatia* is a primitive scyphozoon, retaining many characters of the actinula stage" and that ". . . the fins are probably a homologue of the marginal lappets of the ephyra, though more highly differentiated." Komai lists five lines of evidence which have been used by others to point to the hydrozoan nature of *Tetraplatia*. These lines are as follows: 1. the resemblance of the sense-organ to that of the trachymedusae; 2. the ectodermal gonads; 3. the presence of a velum; 4. the absence of septa and gastral filaments; 5. the absence of cells in the mesoglea. Komai agrees that the sense-organ is hydrozoan in nature and says (p. 245) that ". . . this may be the most questionable point of the scyphozoon theory." He states that items 2 and 3 above are "based on erroneous observations" and that 4 and 5 "are largely larval features." I cannot agree with Komai's conclusions and I feel that he himself has made some erroneous observations and interpretations.

The sense organ (statocyst) of *Tetraplatia* clearly is hydrozoan in nature; this Komai readily admits although he refers to the lithostyle as a rhopalium. The origin of the gonads, although not observed as a developmental phenomenon, seems from a study of histological preparations to be clearly ectodermal. It is true that the gonads have invaded the coelenteron to the extent that they occur embedded in ridges of endodermal tissue but they can be seen to be covered with mesogleal tissue which separates them from the endoderm. Komai illustrates the position of the gonads where they approach the surface at the margin and shows the gonadial tissue covered by a thin layer of ectoderm. There is no indication of any mesoglea between the gonad and ectoderm but he says that mesoglea is inserted between the ectoderm and gonads. Among the six specimens, prepared as serial sections which I studied, five were ripe or nearly ripe adults (four females, one male) and one was an unripe immature individual of undeterminable sex. In the ripe specimens there is a very definite indentation or "pore"

at the point where the gonads contact the surface (behind the buttresses and immediately below the marginal band), and in the male groups of sperm cells were in these pores, and in one female a large ripe egg was half in and half out of one of the pores. In the immature specimen there is a gradual change in cell type from the ectodermal cells to the gonadial cells at the points where the gonads reach the margin. There is no mesoglea separating the ectoderm from the gonad at this point nor is there a definite epithelial layer covering the gonad as indicated by Komai. The conclusion from this is inescapable and obvious that the gonad is ectodermal and is derived as an ingrowth of epithelial ectodermal tissue into the endoderm, carrying with it the mesoglea which encases the adult gonad.

The matter of the presence of a velum is a very difficult point. The hydrozoan velum is a solid structure consisting of two layers of ectoderm separated by mesoglea. The mesoglea may, however, be nearly nonexistent judging from illustrations of velar anatomy of many hydrozoans and indeed the demonstration of mesogleal tissue in an animal like *Hydra* is not simple. Komai has interpreted what Carlgren and Dantan have called *velum* as tentacles and described and drawn them as being composed of a core of polymorphonuclear endodermal cells covered by epithelial cells. I find two details wrong with this conclusion. First the polymorphonuclear cells are not endodermal, but are ectodermal and second these are not tentacles but are part of the velar sheet, two cells thick, the cells of the oral side being thin, flat epithelial cells while the aboral surface is the layer of polymorphonuclear cells. I cannot determine if there is any mesoglea present between these cell layers. In the slides I have examined some sections, through tightly rolled lappets, were rather similar to Komai's figure 9 (Komai 1939, p. 240), but this appearance is the result of the rolling and folding of the velum. In expanded lappets there clearly are no adoral appendages which could be interpreted as Komai has or which occur in the position Komai has indicated. Indeed, I find Komai's whole interpretation of the structure of the lappets to be incorrect. He has indicated that the lappets have on their oral surface a thin epithelial layer, next below this a layer of endodermal motor (muscular) cells with fibrous bases, below these another layer of endoderm (these contain the polymorphic nuclei), next the thick mesogleal layer which supports the lappets and then finally the outer-most layer of thin epithelium on the aboral surface. I find all these structures but cannot subscribe to his interpretations. There is a thin epithelial layer overlying a muscular layer on the oral surface of the lappets; however, both these tissues are ectodermal and are separated from the next layer, the endoderm, not by the fibrous bases of the motor cells but by a thin fibrous layer of mesoglea. A double sub-umbrellar layer of ectoderm is not an unknown feature in the Hydrozoa, the innermost layer being the muscular one. That the layer possessing polymorphonuclear cells is endodermal I do not question, since this layer can be traced through the serial sections and its confluence with the endoderm of the coelenteron is clear. Also the polymorphic nuclei gradually become regular ovoid nuclei near the base of the lappet and become identical in structure to those of the endoderm proper. The thickened aboral layer of mesoglea is a clear-cut structure as is the outer, aboral ephithelium and on their nature Komai and I agree. In my slides it is clear, however, that it is this latter, ectodermal, layer which gives rise to the cells with polymorphic nuclei of the velum and there appears to be no possibility that this could be an endodermal tissue in spite of the similarity of its nuclei and those of part of the endoderm.

Komai dismissed the absence of septa, gastric filaments and cells in the mesoglea as larval features. In the Scyphozoa the septa are well developed in the scyphistoma larva while the cellular mesoglea and gastric fila-

ments make their appearance in the ephyra. Since Komai suggests the "fins" or lappets are the same as those of the ephyra, it seems curious that he could so readily dismiss the absence of these other structures in this animal, *Tetraplatia*, even though he concludes it is neotenic.

I find that I am in complete disagreement with Komai and can only conclude that he has not properly interpreted the structure of this hydrozoan. One further point might be mentioned, however, before the hydrozoan nature of this animal is assured and this concerns the nematocysts. Scyphozoans quite generally possess atrichs, although they, as well, also possess at least one other type, even in the earliest developmental stages (Weill, 1934). This would seem to be further proof that *Tetraplatia* is a hydrozoan, since its cnidom is identical to that of the Narcomedusae. There are certain gross characters of *Tetraplatia* which do suggest the Cubomedusae, and some such organism as *Tetraplatia* conceivably could have been involved in the early evolution of the scyphozoan line, although *Tetraplatia* is clearly a hydrozoan. The problem which now must be solved is, "Where among the Hydrozoa should *Tetraplatia* be placed?" I believe *Tetraplatia* is a trachyline medusa and will now discuss this.

The trachyline medusae are commonly considered to be composed of two orders, the Trachymedusae and the Narcomedusae. The Trachymedusae are defined as possessing free or enclosed lithostyles containing endodermal lithocytes, a simple bell margin and a monocnidom of microbasic euryteles. The Narcomedusae on the other hand possess only free lithostyles, a scalloped bell margin and a monocnidom of atrichous isorhizas. The Narcomedusae also lack a true manubrium and may have peronia and otoporpae. The life histories of the trachylines as a whole lack a polypoid generation and are said to be direct, involving a planula, an actinula, and the adult. The gonads of the trachylines are sub-umbrellar and occupy a position either below the radial canals or in the floor of the stomach pouches (Narcomedusae).

Tetraplatia has a number of characteristics which suggest its affinities to the trachyline medusae and especially to the Narcomedusae. Its swimming plates or lappets can be homologized with the lappets of Narcomedusae as can the adoral stomach pouches which run into the buttresses. Its nematocysts are also narcomedusan. Its sensory structures, the statocysts (enclosed lithostyles), however, are trachymedusan. The position of the statocysts on the adoral lappet surface is, however, an unusual position since all of the trachylines have marginal, ex-umbrellar balance organs. The position of the gonads, below the stomach pouches, is a narcomedusan character unless these pouches are actually homologues of the radial canals. Its manubrium suggests trachymedusan rather than narcomedusan affinities.

As an adult animal, *Tetraplatia* is grossly a very differently constructed medusa than any known Narcomedusae, in spite of its obvious narcomedusan nature. The lack of tentacles, radial and ring canals, and the position and structure of the sensory clubs make it unique. The flying buttresses and the swimming lappets also are without counterparts. The extreme reduction of the sub-umbrellar space gives this animal its non-medusan, planuloid shape.

Carlgren (1909) was so impressed by the peculiarities and unusual structure of tetraplatians that he erected a new order of medusae for them, the Pteromedusae, as a group of equivalent rank to the Trachymedusae and Narcomedusae. This action has not been accepted by other workers as a solution to the systematic position of these animals, and, as has been remarked previously, *Tetraplatia* is usually considered to be a narcomedusan. The Narcomedusae contain several unusual forms such as *Polypodium* and *Hydroctena* and some have very unusual, complicated life histories. In general a hydroid phase is absent in their life histories, although all known seem to involve an actinular larval stage. These

actinulae are in general planuloid, tentacled organisms; the tentacles arising at the place on the circumference which demarks the aboral, ex-umbrellar, area from the oral, manubrial area. In the actinula in its simplest form there is no sub-umbrellar region, but as it grows into a medusa the bell margin grows outward and downward, thus creating the sub-umbrellar space. *Tetraplatia* in form and adult structure strongly suggests its actinular affinities and except for the absence of tentacles seems to be a compromise between the structure of actinula larvae and adult trachyline medusae.

There is very little information to guide us to a decision as to what position *Tetraplatia* should have among the Narcomedusae. Mayer (1910) reviewed the several possible classifications within this group, and recognized only two families, the Solmaridae and Aeginidae; the Solmaridae are without stomach pouches while the Aeginidae possess them. Unfortunately Mayer did not consider *Tetraplatia* at any point in his work. Of these two families of Narcomedusae, *Tetraplatia*, by its possession of a pouched stomach, seems to most closely approach the Aeginidae and within this family it would best be placed within the sub-family Cunanthinae.

Within the Cunanthinae can be placed such genera as *Cunantha*, *Hydroctena*, *Cunoctantha*, and *Cunina*. Of these genera *Tetraplatia* would seem to be most closely related to *Cunantha*, although Mayer (1910, Vol. 2, p. 449) said, ". . . the 'genus' *Cunantha* is, I believe, only a developmental stage of Aegina." *Cunantha* is, however, clearly a medusan and does not grossly suggest *Tetraplatia* by its form, but its special features do suggest some of the special features of *Tetraplatia*. For example, the exumbrella bears rows of nematocysts as in *Tetraplatia* and moreover *Cunantha* has only four broad lappets. The stomach pouches of *Cunantha* are very small and only four in number, again as in *Tetraplatia*. The tentacles of *Cunantha* are rudimentary whereas there are none in *Tetraplatia*. If *Cunantha* exists as a valid genus might not this last character indicate a trend toward loss of tentacles? However, the medusoid form, sensory clubs, numerous statoliths, otoporpae, and gonad ring of *Cunantha* all represent characters quite different from those of *Tetraplatia*.

Broch (1929) in reviewing the classification of the Narcomedusae recognizes three families, the Cuninidae, Aeginidae and Solmaridae. Of the three, again, *Tetraplatia* best fits the definition of the aeginids but at the same time cannot be clearly identified as an aeginid or indeed even as a narcomedusan if one considers its structure and particularly its possession of a statocyst.

Dantan (1925) did not believe that the statocyst of *Tetraplatia* could be considered as derived from the endoderm. Indeed, the whole statocyst is not, nor is it in other trachylines, although the internal cells of the lithostyle are. In *Tetraplatia* it seems to be fairly obvious that the lithostyles, or at least the lithocytes, are endodermal. This character then clearly places *Tetraplatia* among the trachylines. Dantan (1925, p. 452) although disagreeing entirely with Carlgren's classification of *Tetraplatia*, tried to conserve Carlgren's name, Pteromedusae, by making it a family of the Anthomedusae. This was a kind gesture on Dantan's part; however, it is an action contrary to the International Rules of Zoological Nomenclature under which the only allowable family name would have to be Tetraplatiidae if *Tetraplatia* is the type genus.

If *Tetraplatia* is to be placed among the Narcomedusae it will stand out as a very aberrant, highly divergent, form. Its possession of an enclosed lithostyle is a trachymedusan character and the definition of the Narcomedusae would therefore have to be modified to meet this situation. That *Tetraplatia* has strong narcomedusan characters certainly is not to be denied; however, it is an animal that seems to have evolved along a path quite distinct from the normal narcomedusan line. One can hypothesize that *Tetraplatia* is the result of retrogressive evolu-

tion from the aeginid line, or that *Tetraplatia* has evolved directly from primitive narcomedusan ancestors at a point so early that the true medusoid form had not yet been established. If this latter is true, then *Tetraplatia* must represent an early evolutionary experiment in developing a more complex organism than the presumed actinular ancestors of the trachyline medusae. Another suggestion could be that *Tetraplatia* represents a neotenic actinula, and as such might better be called aberrant than primitive. Regardless of which of these hypotheses one might subscribe to, I feel that the unusual characteristics of *Tetraplatia* place it in a position between the two recognized orders of trachyline medusae and that it is morphologically so distinct that it deserves to be placed in an order of its own. I therefore subscribe to the classification proposed by Carlgren (1909) and recognize *Tetraplatia* as a pteromedusan. Further light may be shed on the actual ancestry of *Tetraplatia* once its development and complete life history are known.

The distribution of *Tetraplatia* in the Eastern Pacific, as indicated in Figure 4, presents a pattern in the northern latitudes which one might predict on the basis of known ocean currents. That is, this animal seems to live in the water which slowly moves in a clockwise direction and makes up the North Pacific Current. On this basis one can predict that *Tetraplatia* can be expected to be found throughout this whole current system including the Kuroshio and the North Equatorial Current. Komai (1939) has already reported four specimens from Japan. Further collecting alone will test this suggestion. However, if one examines Figure 4, it will be seen that there is a considerable gap between the most southerly point at which *Tetraplatia* was collected and the main area from which most specimens were taken. That is, no specimens were collected between 5° south latitude and 20° north latitude. The area covered by the lack of specimens was sampled by the Scripps Institution cruise "Shellback" and the specimens taken at 20° N. and 5° S. were from that expedition. Although not all of the plankton tows taken on "Shellback" have been examined by the writer, 18 samples spaced throughout the gap have been examined and no *Tetraplatia* were found. The tows in this area were oblique hauls with a one-meter net fishing from 300 meters depth to the surface. The presence of one specimen of *Tetraplatia* at 5° S. suggests that *Tetraplatia* is present in the cooler waters of the South Pacific, since this specimen was from the northern end of the Peru Current, a cold water mass moving in a counter-clockwise direction. The gap between this cold water mass and the cold water of the North Pacific is filled with the warmer waters of the Equatorial Counter Current and *Tetraplatia* may be unable to live in this area of warmer water. This, perhaps, explains the absence of *Tetraplatia* in the area under consideration, although a possible alternative solution might be in the fact that colder waters underlie the area and *Tetraplatia* may be found there if samples are taken from the deeper waters. If this is so, then the lack of *Tetraplatia* may be an artifact of sampling and the result of tropical submergence as this animal stays in the colder waters which may offer to it a more suitable environment.

CONCLUSION

Tetraplatia volitans is considered, by the author, to be a highly specialized and divergent trachyline medusan of narcomedusan ancestry which has evolved a trachymedusan sense organ. Its adult morphology seems to represent a compromise between the structures of actinula larvae and adult narcomedusans. Its highly specialized lappets and new features such as the flying buttresses and enclosed adoral lithostyles represent unique characters. In order to give proper weight to the unusual nature of this animal, Carlgren's order of Pteromedusae is recognized as a valid classification. *Tetraplatia* is nearly worldwide in distribution and may be characterized as a

holoplanktonic organism which undergoes diurnal vertical migrations.

ACKNOWLEDGMENTS

During the course of my work on *Tetraplatia* I have been materially aided by a number of people who have either collected specimens for me or called my attention to their presence in individual plankton samples. These people are Messrs. Berner, Bieri, Brinton and McGowan of the Scripps Institution of Oceanography, and Mr. Barham of the Hopkins Marine Station. I also wish to thank Dr. M. W. Johnson of Scripps, and Mr. G. F. Gwilliam of the University of California at Berkeley for a critical reading of the manuscript.

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Paranesippus incisus n. gen., n. sp., a New Parasitic Copepod of the Family Pandaridae[1]

SUEO M. SHIINO[2]

BY THE COURTESY of Professor Y. Okada, the director of our faculty, I have been enabled to examine and describe a female copepod representing a new genus and species of the family Pandaridae. According to him it was obtained from the outside surface of *Acanthidium eglantina* (Jordan and Snyder) caught off Kannoura, Kôti Prefecture. Sincere thanks are hereby returned to the named professor for his favours.

Genus PARANESIPPUS n. gen.

FEMALE: Cephalon fused with 1st thoracic segment; carapace with lateral lobes extending back beyond central region. Second to 4th segments distinct; 2nd segment with lateral plates on both sides, 4th with a pair of dorsal plates, and 3rd without either of these. Genital segment much enlarged and entirely coalesced with 6th segment. Abdomen one segmented, attached to ventral surface of preceding segment, and invisible from above. Antennae and maxillipeds as usual. First maxillae transformed into bosses, second maxillae two jointed, close to the sides of elongate conical mouth tube. Sternal furca absent. Four pairs of legs biramose, rami fringed with well-developed plumose spines in all. Both rami two jointed in first pair, three jointed in following two pairs, endopod and exopod three jointed in fourth pair. Fifth leg rudiments present. Caudal rami laminate.

Male unknown.

As the second to fourth thoracic segments are distinct one from another as well as from the carapace, and the four pairs of legs are biramous, the new genus ought to be classified among the family Pandaridae. There are lateral lobes on the second segment, dorsal plates on the fourth, but neither of these on the third, and sixth segment is fused with the fifth. A similar condition prevails in the genera *Nesippus* Heller and *Prosaetes* Wilson. However, the new genus is different from the former in the distinctness of the third segment from the fourth, and from the latter in the shortness of the third segment. Another marked difference from both of these genera is found in the number of joints composing the four pairs of legs, since in these the first three legs have the rami two jointed and the fourth legs have them one jointed.

Paranesippus incisus n. sp.

Type: A single female parasitic on the outside surface of *Acanthidium eglantina* (Jordan and Snyder) caught at a depth of 200–400 m. off Kannoura, Kôti Prefecture (Figs. 1, 2). It will be deposited in Mie Prefectural University.

[1] Contribution No. 22 from the Faculty of Fisheries, Prefectural University of Mie, Tsu-City, Japan. Manuscript received July 26, 1954.

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Body flattened, 8.8 mm. × 4.2 mm., brownish in alcohol.

Carapace orbicular, slightly wider than long including lateral lobes, and less than half as long as entire body. Front prominent, triangular, two sides widely round, with a slight notch about the middle and hind border horizontal. Frontal plates well developed, four fifths as wide as carapace, with a distinct median incision and round lateral ends. Posterior lobes linguiform, blunt, scarcely attaining hind border of third thoracic segment. Longitudinal sutures on dorsal face parallel, their anterior ends far from reaching the front of carapace. Eye inconspicuous.

Second to fourth thoracic segments distinct. Second segment more than two thirds as wide as carapace, one fifth as long as its own width, with reentrant, arcuate hind border, and with quadrate lateral plates, extending outwards and backwards; apices of plates truncate and partly concealed beneath posterior lobes of carapace. Third segment lentiform, as long as, but narrower than, preceding segment, into whose posterior excavation it is fitted. Fourth segment contracted in front into a short narrow neck and expanded in the rear into a pair of circular dorsal plates covering anterior end of succeeding segment; the plates separated from each other by a median sinus. Width of the segment across the plates a little greater than that of third segment, length including the plates a little less than that of second and third segments combined. Genital segment strongly inflated, with length equal to that from the front of carapace to the end of third segment, three fourths as wide as long, elliptical in outline, with gracefully curved sides, but trilobed at the hind end by a pair of deep longitudinal incisions. Median lobe of this end with a horseshoe-shaped outline, much wider than triangular lateral ones, and extending back beyond these. Sides of the segment curled ventrally, forming narrow longitudinal flaps. Abdomen about two sevenths as long as genital segment, more than half as wide as long, somewhat narrowed at anterior end. It is attached to ventral surface of genital segment a short distance behind the center, so as to be entirely concealed in a dorsal view. Egg strings folded several times on either side of abdomen.

First antennae with basal joint relatively narrow, thickly covered with plumose spines on distal portion; apical joint filiform, with simple spinules. Second antennae with an oval boss at the base, claw with its tip damaged in the present specimen, but retaining two spinules. Mouth tube elongate conical, enclosing styliform mandibles. First maxillae transformed into obovate corrugated bosses, close to the bases of first antennae. Second maxillae indistinctly two jointed; basal joint elongate, apical joint short, standing at right angles to the basal and tipped with a short spine. First maxillipeds have two unequal claws, doubly edged with narrow pectinate rim, near the base of claws, a hemispherical boss, thickly covered by fine cirri. Palm of second maxillipeds massive, bearing a short dactyliform basal process; finger broken. A pair of fusiform corrugated bosses present on the sternum in the region just in front of the bases of the named limbs and on either side of the midline.

Four pairs of legs biramose, with rami fringed with well-developed plumose spines in all. Both rami two jointed in first pair, three jointed in succeeding two, inner member two jointed, and outer member three jointed in fourth. Protopodites of both sides widely separated from each other in first and last pairs, rather small in first, but strongly dilated in last. They are fused together forming a wide apron in other pairs. Arrangement of spines on the legs is given in Table 1.

First legs with anterior face of protopodite with very fine, parallel striations. Second legs with bosses covered with similar striations on basal apron, two on anterior face and one on posterior face on each side. Third legs

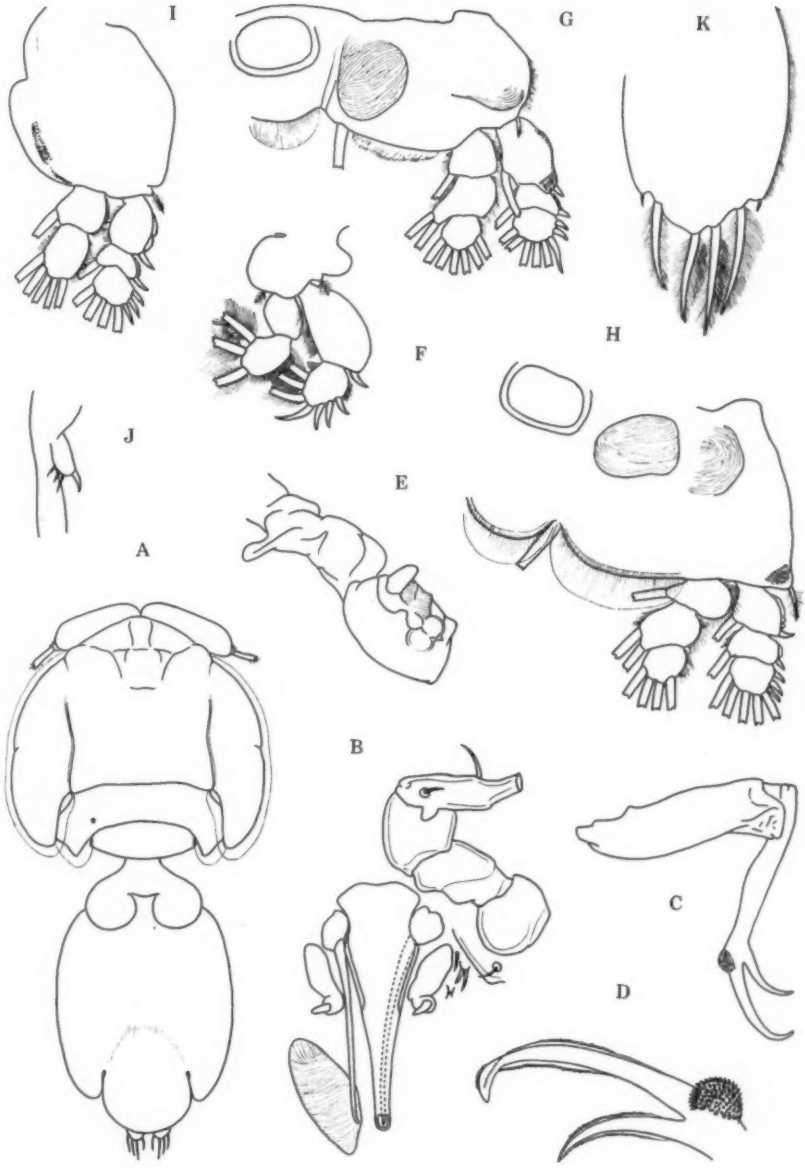

FIG. 1. *Paranesippus incisus* n. gen., n. sp., female. A, Dorsal aspect; B, second antenna, mouth tube, second maxilla and striated boss in front of the base of second maxilliped; C, first maxilliped; D, tip of first maxilliped, further enlarged; E, second maxilliped; F, first leg; G, second leg; H, third leg; I, fourth leg; J, fifth leg; K, caudal ramus. (A × 9.1, B × 41, C, F-K × 37, D × 95, E × 22.)

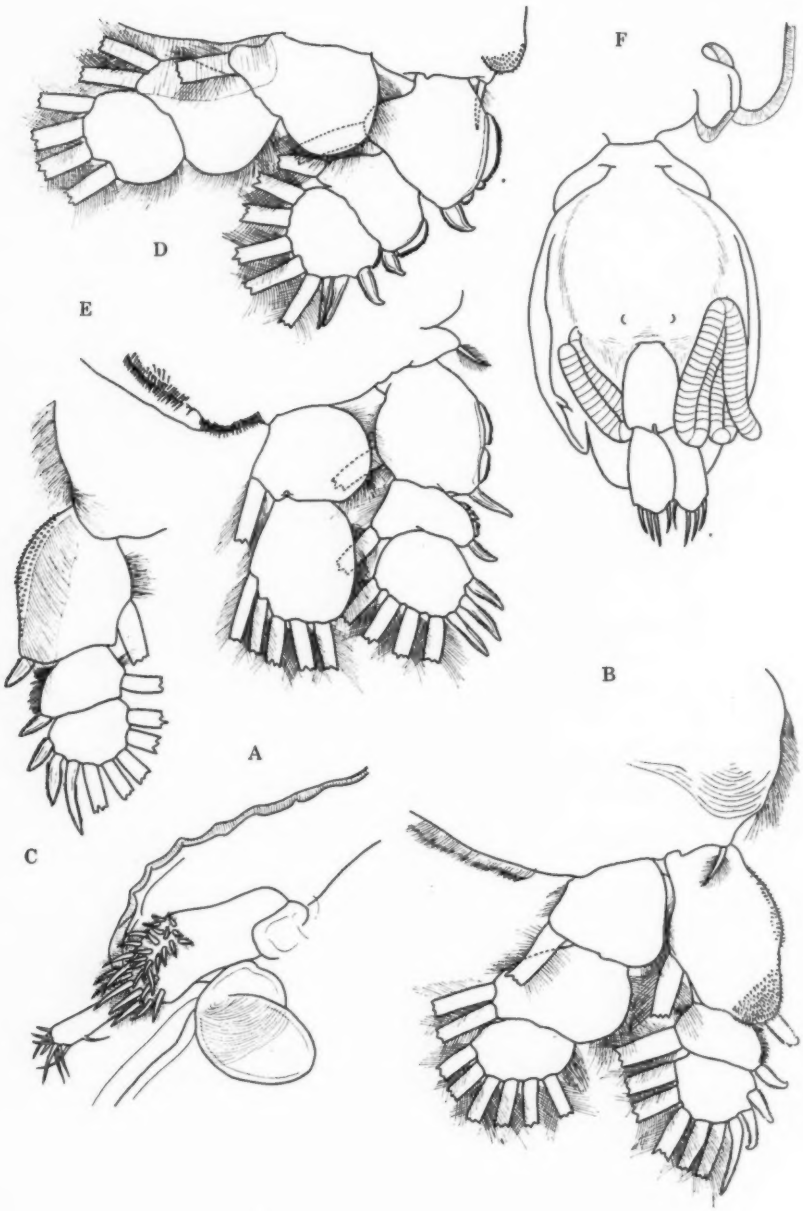

FIG. 2. *Paranessipus incisus* n. gen., n. sp., female. A, First antenna with rudiment of first maxilla; B, second leg; C, exopodite of second leg, posterior face; D, third leg; E, fourth leg; F, posterior part of body, ventral aspect. (A × 41, B-E × 83, F × 12.)

TABLE 1
DETAILS OF THE ARMATURE OF THE LEGS OF *Paranesippus incisus* N. SP.

LEG	BORDER	STERNAL PLATE	PROTOPODITE	EXOPODITE			ENDOPODITE		
				I	II	III	I	II	III
I.....	outer inner		1p 1p	1H c	c, 4H c, 3P			c 3P	
II.....	outer inner	f	c, 1p 1P, f	C, f, 1H c, 1P	C, 1H c, 1P	3H 5P	c c, 1P	c c, 2P	c 6P
III.....	outer inner	f	C, 1p 1P, f	C, 1H c, 1P	C, 1H c, 1P	C, 3H 5P	c 1P	c c, 2P	c 4P
IV.....	outer inner		1p C	C, 1H c, 1P, c	C, 1H c, 1P	3H 4P	c 1P	c c, 5P	

Abbreviations: C, row of cirri; c, row of hairs; f, flange formed by fusion of hairs; H, simple spine; P, longer plumose spine; p, shorter plumose spine. Roman numerals indicate the numerical orders of legs or of joints, arabic numerals the numbers of spines and setae present on them.

with two pairs of bosses only on anterior face. Cirri on outer margin of exopodite of last two legs more or less fused together forming pectinate rims. Those on first exopodite joint of second legs and those at outer angle of protopodite of third legs cover a somewhat wider area. Non-plumose spines on exopodite of all legs with double row of fine pectination. Fifth leg rudiments are small, oboval papillae located on side flaps of genital segment at about its posterior one-third. They are armed with a short apical spine and with three setae on outer border. Caudal rami as long as abdomen, with four subequal plumose spines which are interposed between two minute spinules, and with finely ciliated inner border. Male unknown.

In addition to the generic characters, the present species is distinguished from the known species of *Nesippus* and *Prosaetes* by its trilobed genital segment. The median lobe probably represents the fused sixth segment, which is distinct in some other pandarids, for it is demarked from the fifth segment proper by an inconspicuous, anteriorly arched, surface groove.

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Algal Collections from Funafuti Atoll

V. J. CHAPMAN[1]

IN SEPTEMBER, 1951, H.M.S. "Challenger" visited Funafuti Atoll in the Ellice Islands in connection with seismic experiments. Biological materials were collected from the reef and samples were dredged from the floor of the lagoon. No algal material was collected in the latter but some was obtained from the reef stations, the location of which is shown in Figure 1. In the report accompanying the material (Challenger 2320/12/3) it is stated that the seaweed samples are good random ones. Considerable differences in respect to both abundance and proportions of species are evident at the various stations. No algal collections appear to have been made on previous visits, not even during the celebrated visit to put down the bore through the reef in order to determine the depth of coral (Finckh, 1904). Recently an extensive treatment of the algae of Bikini Atoll has been published (Taylor, 1950) and this has proved very helpful in the present study. The list of species from Funafuti is not as extensive as one might have expected but this may be a result of the lack of a trained botanist among the collectors.

I am grateful to Dr. Drouet for checking one or two doubtful species among the Myxophyceae and to Dr. Yale Dawson for the identification of *Wurdemannia miniata*. The collection has been deposited at the Auckland Institute and Museum, Auckland, New Zealand.

MYXOPHYCEAE

OSCILLATORIACEAE:

Lyngbya majuscula (Dill.) Harv. Sta. 1 (lagoon side; seaward side); Sta. 2 (seaward side); Sta. 3 (seaward side).

Lyngbya confervoides C. Ag. Sta. 2 (seaward side); Sta. 4 (seaward side); Sta. 5.

Lyngbya semiplena (C. Ag.) J. Ag. Sta. 5.

Oscillatoria nigro-viridis Thw. Sta. 1 (seaward side).

Phormidium corium (Ag.) Gom. Sta. 4 (seaward side).

Hydrocoleus lyngbyaceus Kutz. Sta. 4 (seaward side).

Hydrocoleus coccineus Gom. Sta. 4.

RIVULARIACEAE:

Calothrix confervicola Kütz. Sta. 4 (lagoon side).

CHLOROPHYCEAE

ULVACEAE:

Enteromorpha procera (Ahl.) f. *minuta* Chap. Sta. 5.

SIPHONOCLADACEAE:

Cladophoropsis membranacea (Ag.) Borg. Sta. 2 (seaward).

[1] Auckland University College, Auckland, New Zealand. Manuscript received November 29, 1954.

Cladophoropsis membranacea (Ag.) Borg. var. *repens* Phinney. Sta. 4.

Cladophoropsis zollingeri (Kütz.) Borg. Sta. 2 (seaward).

BOODLEACEAE:

Boodlea siamensis Reinbold. Sta. 1 (lagoon and seaward sides).

Struvea anastomosans (Harv.) Picc. et Grun. ex Piccone. Sta. 2 (seaward).

ANADYOMENACEAE:

Microdictyon setchellianum Howe. Sta. 4; Sta. 5.

Microdictyon japonicum Setchell. Sta. 4 (seaward). The plants were young but appeared to belong to this species.

VALONIACEAE:

Dictyosphaeria cavernosa (Forsk.) Borg. Sta. 2 (seaward); Sta. 3; Sta. 4 (lagoon and seaward sides); Sta. 5.

Dictyosphaeria versluysii Weber v. Bosse. Sta. 5. One plant which agrees with the description in Egerod (1952) is present.

Valonia ventricosa J. Ag. Sta. 1 (lagoon).

Valonia aegagropila C. Ag. Sta. 2 (seaward); Sta. 4 (seaward); Sta. 5.

DASYCLADACEAE:

Neomeris van-bosseae Howe. Sta. 4.

Acetabularia parvula Solms-Laubach. Sta. 1 (seaward).

CODIACEAE:

Avrainvillea pacifica Gepp. Sta. 5.

Halimeda opuntia (L.) Lamx. f. *triloba* Barton. Sta. 2 (lagoon); Sta. 3.

Halimeda opuntia (L.) Lamx. f. *elongata* (Barton) Barton. Dredged in 25 fathoms, 1.5 miles south of Fualifeke.

Halimeda tuna Lamx. var. *platydisca* (Dec.) Barton. Sta. 2 (lagoon side).

Halimeda incrassata (Ell. et Sol.) Lamx. Sta. 4 (lagoon side).

Halimeda gracilis Harv. f. *lata* Taylor. Dredged at 25 fathoms, 1.5 miles south of Fualifeke.

CAULERPACEAE:

Caulerpa urvilliana Mont. v. *typica* Weber-v.-Bosse. Sta. 5.

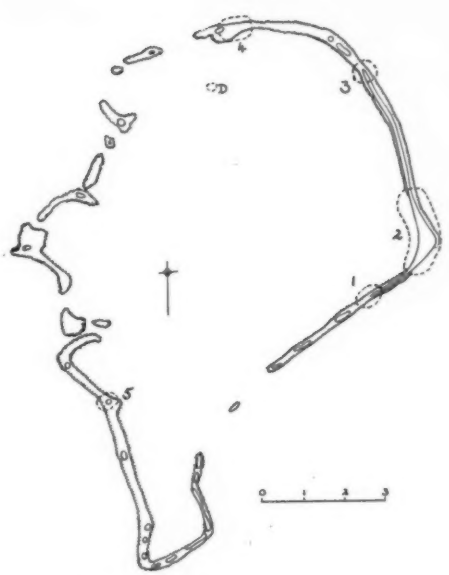

FIG. 1. Map of Funafuti Atoll showing the stations from which algal samples were collected and the place (D) where the dredged sample was obtained. Scale in nautical miles.

Caulerpa racemosa (Forsk.) J. Ag. v. *uvifera* (Turn.) Weber-v.-Bosse. Sta. 3.

Caulerpa racemosa (Forsk.) J. Ag. v. *uvifera* (Turn.) Weber-v.-Bosse f. *planiuscula* Svedel. Sta. 2 (lagoon side).

Caulerpa cupressoides (Vahl.) Ag. v. *typica* Weber-v.-Bosse. Sta. 3.

PHAEOPHYCEAE

ECTOCARPACEAE:

Ectocarpus indicus Sonder. Sta. 1 (seaward); Sta. 5.

DICTYOTACEAE:

Pocockiella variegata (Lamx.) Papenfuss. Sta. 1 (lagoon and seaward); Sta. 5.

Padina commersonii Bory. Sta. 2 (lagoon side). Probably this species though the material was sterile.

Dictyota dichotoma Lamx. Sta. 2 (seaward side).

Dictyota dichotoma Lamx. forma. The plant appeared to belong here but was broad at the apex, narrowing somewhat to the base. Dredged at 25 fathoms, 1.5 miles south of Fualifeke (D in Fig. 1).

Dictyota bartayresiana Lamx. Sta. 2 (lagoon side). The plant agreed generally with this species.

RHODOPHYCEAE

CHAETANGIACEAE:

Galaxaura filamentosa Chou. Sta. 2 (seaward side); Sta. 3.

GELIDIACEAE:

Wurdemannia miniata (Lamx. & DC) Feldm. & Hamel. Sta. 1 (seaward); Sta. 2 (seaward).

CORALLINACEAE:

Jania rubens Lamx. Sta. 1 (seaward); Sta. 2 (seaward); Sta. 4 (seaward); Sta. 5.

MELOBESIACEAE:

Fosliella farinosa (Lamx.) Howe. Sta. 2 (on *Struvea anastomosans*).

GRACILARIACEAE:

Gracilaria coronopifolia J. Ag. Sta. 1 (seaward side); Sta. 2 (seaward side).

RHODOMELACEAE:

Laurencia intricata Lamx. Sta. 1 (seaward side); Sta. 2 (seaward).

Herposiphonia tenella (C. Ag.) Naeg. Sta. 1 (lagoon and seaward sides); Sta. 2 (seaward); Sta. 5.

Herposiphonia secunda (C. Ag.) Ambronn. Sta. 2. (seaward).

Roschera calodictyon (Harv.) Weber-v.-Bosse. Sta. 2 (seaward).

CERAMIACEAE:

Centroceras clavulatum (C. Ag.) Mont. Sta. 1 (seaward side); Sta. 5.

Ceramium personatum Setch. & Gard. Sta. 4 (lagoon side). The plants appeared to belong to this species.

Ceramium sp. Sta. 1 (seaward).

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A Tornatellinid Land Mollusk from the Solomon Islands

R. K. DELL[1]

THE FAMILY TORNATELLINIDAE is widely distributed in the Pacific. In the Western and Southwestern Pacific it has been recorded from the East Indies, New Guinea, New Caledonia, Lord Howe Island, Norfolk Island, Australia, the Kermadec Islands, and New Zealand. No records appear to exist for the family in the Solomon Islands. Mr. R. R. Forster collected some land snails on Savo Island in 1944, and among these was a tube of tornatellid snails. They prove to belong to the genus *Lamellidea* and are here described as new. The small land Mollusca of the Solomon Islands have been only superficially collected and this and other forms of the Tornatellinidae will probably prove to be widely distributed in the group.

LAMELLIDEA Pilsbry, 1910

1910 *Lamellidea* Pilsbry, *Nautilus* 23: 123.
Genotype: "*Pupa*" *peponum* Gould.

Lamellidea solomonensis n. sp.
Fig. 1

Shell imperforate, oblong-conic, reddish brown, faintly translucent. Surface rather shining, marked with irregular growth striae. Spire convex in outline, apex obtuse. Suture rather appressed; whorls somewhat constricted below the suture. Whorls five and a half to six, marked with rather irregular growth lines; last whorl comparatively large, about two thirds the total length of the shell. Aperture comparatively small, ovate, slightly oblique. Adult shell with a single parietal lamella, its outer margin flaring outwards and to a varying extent, downwards. Palatal wall without teeth or lamellae in most adult shells, columella vertical, twisted to a varying degree, with an obsolete tooth in some specimens. Peristome thin, flattened in the middle.

The armature of juvenile shells is more complex. The parietal lamella is more strongly developed and is folded on itself. The columella bears a strong tooth and this is backed by a weaker tooth set higher on the columella and further back in the aperture in some specimens. The remains of the stronger columellar tooth persist into the adult stage in some specimens. There are also widely spaced vertical palatal barriers as in *L. serrata* (Pease) and *L. subcylindrica* (Quadras and Moellendorff). These barriers also may persist into the subadult stage. The degree of development of serrations on these palatal barriers also varies considerably.

Savo Island, Solomon Islands, collected R. R. Forster, May, 1944. Holotype (M. F. 2505) and paratypes (M. F. 2506) in Dominion Museum, Wellington, New Zealand. Paratypes in Bernice P. Bishop Museum, Honolulu.

[1] Dominion Museum, Wellington, New Zealand.
Manuscript received November 9, 1954.

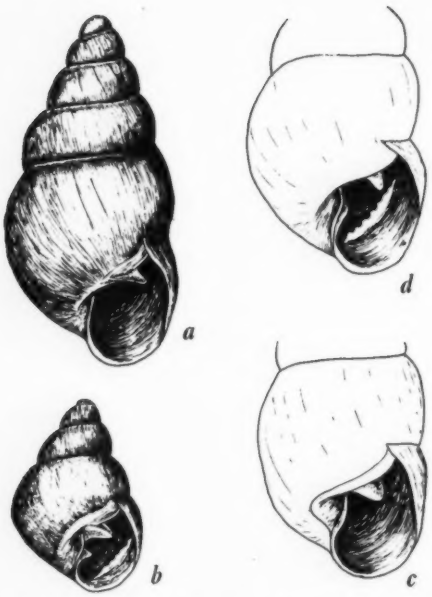

FIG. 1. *Lamellidea solomonensis* n. sp. *a*, Holotype, 2.95 × 1.54 mm.; *b*, juvenile shell, 1.68 × 1.14 mm.; *c*, aperture of six-whorled paratype, 3.32 × 1.5 mm.; *d*, aperture of five-and-a-half-whorled paratype, 3.0 × 1.54 mm.

TABLE 1

DATA ON THE SHELLS OF *Lamellidea solomonensis* N. SP.
(Measurements in Millimeters)

	HOLOTYPE	PARATYPE	PARATYPE
Number of whorls	5½	6	5½
Length	2.95	3.32	3.0
Diameter	1.54	1.54	1.54
Length of last whorl	1.82	1.95	1.86
Aperture axis	1.04	1.09	1.04
Diameter	0.68	0.77	0.68

Lamellidea solomonensis is closely related by shell characters to *L. microstoma* (Quadras and Moellendorff) and *L. subcylindrica* (Quadras and Moellendorff) from the Mariana Islands. From *L. microstoma* it differs in the outline of the whorls and the subsutural constriction and from *L. subcylindrica* it may be distinguished by the slightly appressed suture and the subsutural constriction. The occasional channelling of the body whorl about the middle in *L. subcylindrica* is foreshadowed in the flattening of the body whorl in *L. solomonensis*.

The genus *Lamellidea* has been recorded from the Polynesian islands as far to the east as Hawaii, from the Marshall, the Mariana, and the Bonin Islands.

An Analysis of the Genera of Surgeon Fishes (Family Acanthuridae)[1]

JOHN E. RANDALL

THE GENERA OF FEW families of tropical marine fishes have been as badly confused as those of the Acanthuridae. Ahl (1923: 36) and others have pointed out the need for a review of the generic classification of the family. As may be seen in the key below, the genera are easily distinguished; most of the inconsistency with respect to use of names has been purely nomenclatorial.

The genera fall into two major groups on the basis of the armature of the caudal peduncle. Four of them, *Acanthurus*, *Ctenochaetus*, *Zebrasoma*, and *Paracanthurus*, are characterized by a single folding spine on each side of the peduncle. *Naso* and *Prionurus* have one to six fixed spines or plates in this region. Such a clear-cut distinction might tempt one to treat the two groups as subfamilies. There is, however, a sharing of other important characters by various genera in both groups which makes such a consideration untenable. In this paper the phylogenetic interrelationships of the surgeon fish genera are discussed, and an attempt is made to put the generic classification in order.

The four genera with the single folding spine on the caudal peduncle are being revised. The revision of *Ctenochaetus* is completed (Randall, 1955). Those of *Zebrasoma*, *Paracanthurus*, and *Acanthurus* will follow.

[1] A portion of a thesis submitted to the Department of Zoology, University of Hawaii, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Contribution No. 67 of the Hawaii Marine Laboratory in cooperation with the Department of Zoology and Entomology, University of Hawaii. Manuscript received November 8, 1954.

KEY TO THE GENERA OF ACANTHURIDAE

1a. 1 to 6 immovable keel- or thorn-like spines or laminae on each side of caudal peduncle; least depth of caudal peduncle contained 3.5 to 6 times in length of head; dorsal and anal spines stout 2

1b. A single folding spine on each side of caudal peduncle; least depth of caudal peduncle contained 2.1 to 3.5 times in length of head; dorsal and anal spines slender (except *Paracanthurus*) 3

2a. 1 to 2 pairs of caudal spines or laminae; pelvic fin rays I, 3; anal spines II; dorsal spines IV to VII; teeth small, conical with tips slightly compressed, smooth or with very small denticulations. (Indo-West-Pacific) . . . . . **Naso**

2b. 3 to 6 pairs of caudal spines or laminae; pelvic fin rays I, 5; anal spines III; dorsal spines VIII or IX; teeth moderately large, flattened, close-set, with large denticulations. (Japan, Australia, tropical eastern Pacific, Galapagos Islands) . . . . . **Prionurus**

3a. Pelvic fin rays I, 3; scales on head modified to tuberculated plates. (Indo-West-Pacific) . . . . . **Paracanthurus**

3b. Pelvic fin rays I, 5; scales on head not modified to tuberculated plates 4

4a. Dorsal spines VI to IX (usually VIII or IX); length of longest dorsal ray contained 3.5 to 6 times in standard length;

scales not elevated and ctenii not long; least depth of caudal peduncle 2.1 to 3.2 in length of head; caudal peduncle spine in a sharply-defined groove 5

4b. Dorsal spines IV or V; length of longest dorsal ray contained 2.2 to 3.8 times in standard length; scales elevated and with long ctenii; least depth of caudal peduncle 3 to 3.5 in length of head; caudal peduncle spine in a shallow depression. (Indo-West-Pacific) . . . . . **Zebrasoma**

5a. Teeth fixed, not attenuate with expanded incurved tips, denticulate on both lateral and medial margins, and not over 26 in upper jaw; dorsal spines IX (except one species with VI or VII and two with VIII). (Circumtropical) . . . **Acanthurus**

5b. Teeth movable, attenuate with expanded incurved tips which bear only lateral denticulations, and from 30 to 60 in upper jaw (of specimens over 75 mm. in standard length); dorsal spines VIII. (Indo-Pacific) . . . . . **Ctenochaetus**

The relationship of the existing genera of surgeon fishes is not easily fitted into a conventional family tree pattern. Aoyagi (1943: 196) has constructed such a tree for the Acanthuridae on the basis of dentition alone. For this one character his conclusions are well drawn. *Naso*, with its conical teeth, is listed as most primitive. *N. lituratus* (Bloch and Schneider) and *N. unicornis* (Forskål) exemplify those species of this genus which have teeth lacking denticulations. Others, like *N. hexacanthus* (Bleeker), have tiny denticulations and are higher in the evolutionary sequence. *Prionurus*, *Paracanthurus*, *Zebrasoma*, and *Acanthurus* are progressively more specialized, though these four genera are basically similar. The teeth have become close-set, flattened, and strongly denticulate. *Ctenochaetus*, which has comb-like teeth, is portrayed as being derived from *Acanthurus*.

This picture is strengthened by a consideration of food habits of the genera. The acanthurids, in general, are herbivorous. *Naso* tends to feed on leafy algae such as *Sargassum;* its teeth are not efficient for feeding on slick, filamentous algae. The flattened, denticulate teeth of the next four genera might represent a specialization for feeding on fine algae. *Ctenochaetus* with its numerous, long, protruding teeth can feed effectively on loose algal filaments and other detrital material on the bottom.

When, however, characters other than dentition are considered, the interrelationships of the genera are not so simple. *Naso* and *Prionurus*, both with fixed caudal spines, have different numbers of pelvic rays. *Paracanthurus*, which has a movable caudal spine and is separated from *Naso* by *Prionurus* in the phyletic line of Aoyagi, has a pelvic formula of I, 3 like *Naso*. It appears then that the reduction in pelvic fin rays from I, 5 to I, 3 must have occurred independently in *Naso* and *Paracanthurus* or that the I, 5 condition was secondarily regained in *Prionurus*. The dorsal spines in *Naso* are IV to VII. In *Prionurus* and *Paracanthurus* they are VIII or IX. In *Zebrasoma* they drop to IV or V, and in *Acanthurus* and *Ctenochaetus* they increase again to VIII or IX. The scales present an even more perplexing problem. The supposedly advanced genera, *Acanthurus* and *Ctenochaetus*, have ctenoid scales which are less specialized than the unusual raised and often spinulous scales of the other genera. It is difficult to place *Acanthurus* in a more primitive position than *Naso*, however, for it does not seem that a folding caudal spine and denticulate teeth could precede a fixed spine and smooth teeth. Perhaps the linear pattern of evolution postulated by Aoyagi would be less likely than one which supposes that all the Recent genera (except *Ctenochaetus*, which does appear to be derived from *Acanthurus*) arose from common stock at essentially the same period of geologic time.

Eastman (1904*a*) has commented on the sudden appearance in the Eocene of a host of modern teleost types, many of which were

as highly specialized then as they are today. The fossil record of the Acanthuridae indicates that both *Naso* and *Acanthurus* date back to the Eocene (Agassiz, 1838; Woodward, 1901; Eastman, 1917), thus these are among the specialized genera making the apparent sudden appearance in the early Tertiary.

Hussakof (1907) recorded a fossil *Zebrasoma* (as *Z. deani*) from the West Indies. The specimen, which was well preserved, was considered possibly of Eocene age. In my opinion this fish is not a *Zebrasoma*. It lacks the great depth of body and elevated fins of this genus. Also there is a very narrow caudal peduncle and a crescentic (high and narrow) caudal fin, and no caudal peduncle spines were located. Of existing genera, it seems closest to *Naso*. This specimen, which was deposited in the American Museum, should be re-examined and its position within the Acanthuridae re-evaluated.

Two extinct genera, *Aulorhamphus* de Zigno (Eocene) and *Apostasella* Whitley (new name for *Apostasis* Gorjanovič-Kramberger) (Oligocene-Miocene) have been included in the Acanthuridae although no caudal peduncle spines have been found for these forms. Ogilby (1916: 173) views "with grave suspicion" the inclusion of these genera in the surgeon fish family. I concur in this doubt.

The fossil *Acanthurus gaudryi* de Zigno and *A. gazolae* Massalongo were considered by Woodward (1901) and Eastman (1904*a*) as not belonging to the genus *Acanthurus*. Woodward believed they might be better placed in the Chaetodontidae. Eastman thought them types of distinct genera, but preferred to include them in *Pygaeus* Agassiz, the limits of which were widely extended by Agassiz. In Jordan's opinion (Eastman, 1904*b*), *Pygaeus* is a generalized type ancestral to the Chaetodontidae, Acanthuridae, and Teuthididae (Siganidae). Berg (1947: 482) thought the VIII or IX anal spines of some *Pygaeus* allies it more closely with the latter than with the other two families.

It is evident that more study of the fossil Acanthuridae and related families is needed, with especial effort to integrate knowledge of fossil with that of present forms and to reconstruct the evolutionary picture in more precise terms.

Genus NASO Lacépède

Naso Lacépède, 1801. Hist. nat. poiss. Vol. 3, p. 105. (Type species by subsequent designation (Valenciennes, 1837, pl. 72, fig. 1), *Naso fronticornis* Lacépède = *Chaetodon unicornis* Forskål.)

Monoceros Bloch and Schneider, 1801. Syst. ichth. p. 180. [Preoccupied by Lacépède (*ex* Plumier), 1798. Hist. nat. poiss. Vol. 1, p. 357, in reference to a balistid.]

Nasonus Rafinesque. 1815. Anal. natur. p. 88. (Substitute name for *Naso*.) [Reference after Gill, 1885.]

Priodon Quoy and Gaimard. Voyage autour du monde . . . *Uranie* . . . Zool. p. 377. (Type species, *Priodon annulatus* Quoy and Gaimard.)

Naseus Cuvier. 1829. Règne animal. Ed. 2, vol. 2, p. 224. (Type species, *Naso fronticornis* Lacépède = *Chaetodon unicornis* Forskål.)

Priodontichthys Bonaparte, 1833. Saggio. distrib. metod. anim. vert. p. 34. (Type species, *Priodon annularis* Cuvier and Valenciennes = *Priodon annulatus* Quoy and Gaimard.) [Reference after Gill, 1885.]

Axinurus Cuvier and Valenciennes, 1835. Hist. nat. poiss. Vol. 10, p. 299. (Type species, *Axinurus thynnoides* Cuvier and Valenciennes.)

Keris Cuvier and Valenciennes, 1835. Hist. nat. poiss. Vol. 10, p. 304. (Type species, *Keris anginosus* Cuvier and Valenciennes.)

Callicanthus Swainson, 1839. Nat. hist. . . . fishes . . . Vol. 2, p. 256. (Type species, *Aspisurus elegans* Rüppell = *Acanthurus lituratus* Bloch and Schneider.)

Ceris Kner, 1865. Akad. Wiss. Wien, Denkschr. 24: 6.

Cyphomycter Fowler and Bean, 1929. U. S. Natl. Mus., Bul. 100, vol. 8, p. 264. (Type species, *Naso tuberosus* Lacépède.) (Proposed as a subgenus; raised to generic rank by Smith, 1951: 1126.)

Prionolepis Smith, 1931. Albany Mus., Rec. 4: 125. (Type species, *Prionolepis hewitti* Smith = *Chaetodon unicornis* Forskål.)

The genus *Naso* has been split by some authors into two or more genera. A frequent basis for this division has been the presence or absence of a horn on the forehead in adults. I do not believe that this is a valid means of separation in view of the late appearance of this character, the difficulty at times in assessing what is a horn and what a mere bony prominence, and the demonstration by Smith (1951: 1126) that the horn occurs only on the male in *Naso rigoletto* Smith.

The use of the name *Axinurus* Cuvier and Valenciennes by Fowler and Bean as a subgenus for *Naso thynnoides* (Cuvier and Valenciennes), which has a single buckler on each side of the caudal peduncle, seems more reasonable than applying this name as a genus as has Smith (1951: 1126).

Quoy and Gaimard (1824: 375) erroneously used the generic name *Aspisurus* Lacépède (= *Acanthurus* Forskål) for a species of *Naso*. Lesson (1830: 151) did the same with *Prionurus* Lacépède. Shaw (1803) applied the name *Acanthurus* to all of the species of surgeon fishes (which included *Naso*) in his *General Zoology*. Jordan and Fowler (1902: 558) used *Acanthurus* for species of *Naso* which have an elongate horn on the forehead in the adult (see section under *Acanthurus* for discussion of this).

Keris and *Prionolepis* were proposed for the late postlarval stage of *Naso*.

Genus PRIONURUS Lacépède

Prionurus Lacépède, 1804. Mus. Natl. de Hist. Nat., Ann. 4: 211. (Type species by monotypy, *Prionurus microlepidotus* Lacépède.)

Xesurus Jordan and Evermann, 1896. Checklist fishes N. and Middle America. P. 421. (Type species, *Prionurus punctatus* Gill.)

Acanthocaulus Waite, 1900. Australian Mus., Rec. 3: 206. (Substitute name for *Prionurus*.)

Burobulla Whitley, 1931. Australian Zoologist 6: 321. (Type species, *Xesurus maculatus* Ogilby.)

Triacanthurodes Fowler, 1944. Acad. Nat. Sci. Phila., Monog. 6, p. 332. (Type species, *Naseus laticlavius* Valenciennes.)

Xesurus is distinguished from *Prionurus* by having three to four instead of six keeled laminae on each side of the caudal peduncle. I do not believe that the number of caudal laminae is of generic significance (a specimen of *Prionurus microlepidotus* Lacépède from Port Jackson, Australia, United States National Museum No. 47964, has five keeled laminae on one side of the caudal peduncle and six on the other), and in view of the lack of other differences, I place *Xesurus* in the synonymy of *Prionurus*. There is less basis for the recognition of *Xesurus* than there is for the division of *Naso* into two or more genera.

As pointed out by Gill (1904: 121) Waite was in error in proposing *Acanthocaulus* as a substitute for *Prionurus*. He did so in the belief that *Prionurus* was established by Lacépède in 1830 instead of 1804. In 1829 *Prionurus* was proposed by Ehrenberg in the Arachnida.

The type species for *Burobulla* Whitley and *Triacanthurodes* Fowler clearly belong in the genus *Prionurus*.

Genus PARACANTHURUS Bleeker

Paracanthurus Bleeker, 1863. Ned. Tijdschr. Dierk. 1: 252. (Type species by monotypy, *Acanthurus hepatus* (Linnaeus) Bloch and Schneider = *Teuthis hepatus* Linnaeus, as restricted by Cuvier and Valenciennes.)

Colocopus Gill, 1885. U. S. Natl. Mus., Proc. 7: 277, 279. (Type species, *Colocopus lambdurus* Gill = *Teuthis hepatus* Linnaeus, as restricted by Cuvier and Valenciennes.)

Günther (1873: 115) and subsequent authors continued to use *Acanthurus* for the one known species of the genus *Paracanthurus* after its proposal by Bleeker. The name *Paracanthurus* was unnoticed until Fowler (1926: 139) pointed out that it preceded *Colocopus* Gill.

Genus ZEBRASOMA Swainson

Harpurus Swainson, 1839. Nat. hist. . . . fishes . . . Vol. 2, p. 256. (Not *Harpurus* of Forster, 1778.)

Zebrasoma Swainson, 1839. Nat. hist. . . . fishes . . . Vol. 2, p. 256. (Type species by monotypy, *Acanthurus velifer* Bloch.)

Scopas Kner, 1865–67. Reise . . . fregatte *Novara* . . . Fische. P. 212. (Type species, *Acanthurus scopas* Cuvier and Valenciennes.) (*Scopas* of Bonaparte, 1831, a *nomen nudum*.)

Laephichthys Ogilby, 1916. Queensland Mus., Mem. 5: 173. (Type species, *Acanthurus rostratus* Günther.)

Bleeker (1851) and other authors after him persisted in using the generic name *Acanthurus* for species of *Zebrasoma*, probably without the realization that the latter had been proposed.

Ogilby established the genus *Laephichthys* for the species *Acanthurus rostratus* Günther on the basis of the unusually long snout and thick dorsal spines as shown in a painting by Garrett. Examination of 13 specimens, among them two collected by Garrett from the Society Islands and probably the ones from which the painting was made, revealed considerable variation in snout length. Some specimens had shorter snouts than the average snout length of *Zebrasoma flavescens* (Bennett) or *Z. scopas* (Cuvier). None had thick dorsal spines. No other differences even approaching generic level could be found between *Z. rostratus* and species of *Zebrasoma*; thus *Laephichthys* is not well founded.

Jordan and Jordan (1922: 66) used the name *Scopas* as a subgenus for *Z. flavescens* to emphasize its distinctness from *Zebrasoma* (*Zebrasoma*) *veliferum* (Bloch). *Z. gemmatum* (Cuvier and Valenciennes) tends to invalidate this subgeneric concept, for it has a tooth structure and fin ray counts approaching that of *veliferum*, yet it lacks the extremely elevated dorsal fin of this species and has a body form more like other *Zebrasoma*.

Von Bonde (1934: 449, fig. 3) described a new species of acanthurid, *Hepatus coccinatus*, from Zanzibar. His description and photograph leave little doubt that his specimens are *Zebrasoma veliferum*, although he gave the dorsal spine count as VII instead of the usual IV.

Genus ACANTHURUS Forskål

Hepatus Gronow, 1763. Zoophylacium . . . p. 113. (Nonbinominal.)

Teuthis Linnaeus, 1766. Syst. nat. Ed. 12, vol. 1, p. 507. (Linnaeus included in *Teuthis* several acanthurids and a siganid under the one name *hepatus*. In Opinion 93 of the International Commission on Zoological Nomenclature the siganid, *T. javus*, was fixed as type.)

Acanthurus Forskål, 1775. Descr. animalium. P. 59. (Type species by subsequent designation (Jordan 1917: 33), *Chaetodon sohal* Forskål.)

Harpurus Forster, 1778. Enchiridion hist. nat. . . . p. 84. (Type species, *Harpurus fasciatus* Forster = *Chaetodon triostegus* Linnaeus.) [Reference after Jordan, 1917.]

Rhombotides Walbaum, 1792. (*ex* Klein, 1775, nonbinominal.) Petri Artedi . . . ichthyologiae pars iii, p. 582.

Aspisurus Lacépède, 1802. Hist. nat. poiss. Vol. 4, p. 556. (Type species, *Chaetodon sohal* Forskål.)

Teuthys Swainson, 1839. Nat. hist. . . . fishes . . . Vol. 2, p. 255.

Ctenodon Swainson, 1839. Nat. hist. . . . fishes . . . Vol. 2, p. 255. (Preoccupied by *Ctenodon* Wagler, 1830.)

Acronurus Gronow, 1854. Cat. fish collected . . . p. 190. (Type species, *Acanthurus argenteus* Quoy and Gaimard.)

Zabrasoma Seale, 1901. Bernice P. Bishop Mus., Occ. Pap. 1: 110.

Harpurina Fowler and Bean, 1929. U. S. Natl. Mus., Bul. 100, vol. 8, p. 253. (Type species, *Hepatus nubilus* Fowler and Bean.) (Proposed as a subgenus; raised to generic rank by de Beaufort, 1951: 165.)

Forskål (1775: 59) proposed *Acanthurus* as a subgeneric category of *Chaetodon*, and in it he included *unicornis*, *sohal*, *nigrofuscus*, and *gahhm* (the latter was considered by him as a variant of *nigrofuscus*). None of these was designated by him as the type species. Lacépède (1801: 105) established the genus *Naso* and listed *unicornis* as a synonym of his *Naso fronticornis* (even though *unicornis* is an earlier name). Also (1802: 556) he removed *sohal* (erroneously as *sohar*) from *Acanthurus* and erected the genus *Aspisurus* for this one species. *Aspisurus* has properly been placed back in *Acanthurus*; *unicornis* remains in *Naso*. Valenciennes (1837, pl. 71, fig. 2) figured *Acanthurus xanthopterus* Cuvier and Valenciennes as the type species of *Acanthurus*. Gill (1885: 278) listed "*Teuthis hepatus* Linnaeus = *Acanthurus chirurgus* Bloch" as the type. Neither of these type designations is valid, for these species were not among those included by Forskål in *Acanthurus*.

Jordan and Fowler (1902: 558) used the genus *Acanthurus* for species of *Naso* which have the frontal horn, under the belief that *unicornis* should be considered as the type of *Acanthurus* since it was the first species listed by Forskål in his subgeneric category *Acanthurus*. I quote Jordan and Fowler: "The first species named by Forskål, *unicornis* being taken as its type, *Acanthurus* becomes equivalent to *Monoceros*." Later Jordan (1917: 33) selected *Chaetodon sohal* Forskål as the type species of *Acanthurus*, and both Jordan and Fowler reverted to the usual use of *Naso*. Should Jordan and Fowler's statement on *unicornis* be construed as a valid type designation, I would recommend application to the International Commission on Zoological Nomenclature to preserve the common usage of *Acanthurus* and *Naso*.

According to Opinion 21 of the International Commission on Zoological Nomenclature, the genera of Klein (1744) do not gain nomenclatorial status by reason of being quoted by Walbaum (1792); thus *Rhombotides* is not valid. Bleeker often used this name instead of *Acanthurus*.

The genus *Harpurina* Fowler and Bean, in which de Beaufort (1951: 165) placed the single species *nubilus* Fowler and Bean, is characterized primarily by small teeth and VI or VII dorsal spines. *Acanthurus thompsoni* (Fowler) and *A. bleekeri* Günther have the same type of dentition (and other similarities), but the usual IX dorsal spines. They serve to connect *nubilus* with more typical species of *Acanthurus;* thus I do not believe that *Harpurina* is a valid genus.

Fowler (1944: 109) established the subgenus *Rhomboteuthis* for the species *Acanthurus coeruleus* Bloch and Schneider on the basis of its deep body, long pectoral fins, and small caudal spine. If only the Atlantic species of *Acanthurus* were classified, such a subgenus might be a useful criterion, but it breaks down when the Indo-Pacific forms are considered, for some, like *Acanthurus guttatus* Bloch and Schneider and *A. nubilus*, have a body depth as great or greater and pectoral fins as long as *A. coeruleus*, and *A. triostegus* (Linnaeus) has a smaller caudal spine. None of these species could be grouped with *coeruleus* to form a natural subgeneric category apart from other species of *Acanthurus*. Better subgenera could be formed by grouping *A. achilles* Shaw, *A. glaucopareius* Cuvier, and *A.*

leucosternon Bennett or *A. nubilus*, *A. bleekeri* Günther, and *A. thompsoni* (Fowler); however, I do not believe that even these are advisable.

The late postlarval *Acanthurus* is quite different from the juvenile. It is more disc-like, transparent in life with silvery abdomen, and naked with vertical striae or folds on the body. It is not difficult to understand why Gronow erected *Acronurus* for this stage and how this genus persisted so long in the literature. Although now well known to be larval, acronurus remains as a common name for the late postlarval stage of *Acanthurus*. Some authors apply the designation to all postlarval acanthurids.

The type species of *Acronurus* by subsequent designation is *Acanthurus argenteus* Quoy and Gaimard. As indicated by Randall (in press), this species may be the young of *Ctenochaetus striatus* (Quoy and Gaimard). If this could be conclusively demonstrated, the generic name *Ctenochaetus* would have to be replaced by *Acronurus*. Under such circumstances, it would be advisable to apply to the International Commission on Zoological Nomenclature to conserve the name *Ctenochaetus*. Nearly all use of *Acronurus* has been for the young of *Acanthurus*.

Swainson (1839) listed *Teuthys* as a surgeon fish genus (an emendation or erroneous spelling for *Teuthis* Linnaeus) for the single species *Acanthurus argenteus* Quoy and Gaimard. His brief description of the genus obviously applies to an acronurus. Linnaeus, however, did not include any acronurus forms in *Teuthis*.

Seale placed in *Zabrasoma* (probably a typographical error for *Zebrasoma*), his new species *agaña* (= *flavescens*) and a species of *Acanthurus* (*A. guttatus*). He apparently mistook *A. guttatus* for a *Zebrasoma* because of its high body.

Genus CTENOCHAETUS Gill

Ctenodon Klunzinger, 1871. Synopsis Fische Rothen Meeres. Pt. 2, p. 509. (Preoccupied by *Ctenodon* Wagler, 1830.)

Ctenochaetus Gill, 1885. U. S. Natl. Mus., Proc. 7: 279. (Type species by original designation, *Acanthurus strigosus* Bennett.)

Ctenodon was first proposed by Wagler (1830) for a reptile. Swainson (1839) used the same generic name for five species of *Acanthurus* and one *Ctenochaetus*. Klunzinger applied the name as a subgenus for the species *Acanthurus ctenodon* Cuvier and Valenciennes (= *Acanthurus striatus* Quoy and Gaimard) and *Acanthurus strigosus* Bennett. Fowler (1904: 545) elevated Klunzinger's subgenus to a genus.

The use by Day (1889: 143) (and subsequent authors) of *Acanthurus* for *Ctenochaetus* (and *Teuthis* for *Ctenochaetus* by Barnard, 1927: 780) appears to be due to ignorance of Gill's name *Ctenochaetus* for this well-differentiated genus.

As is indicated in the discussion of *Acronurus* in the section on *Acanthurus* there is a possible question as to the validity of the name *Ctenochaetus*.

SUPPLEMENTAL NOTE

After the present paper was submitted, an article by Prof. J. L. B. Smith, entitled *East African Unicorn Fishes from Mozambique*, appeared in the South African Journal of Science (65 (6): 169–174). Five genera (here considered only as the single genus *Naso*) and *Prionurus* were split off from the Acanthuridae on the basis of caudal armature and placed in a separate family, the Nasidae.

If only the genera *Naso* and *Acanthurus* were considered, such a division would be tenable. It is not, however, when all of the genera are considered. *Paracanthurus* has the single folding caudal spine, strongly denticulate teeth, IX dorsal and III anal spines like *Acanthurus*, but I, 3 pelvic rays and thickened dorsal spines like *Naso*. *Prionurus*, linked with *Naso* by Smith because of the three to six fixed caudal spines or laminae on each side of the caudal peduncle, has a pelvic formula of I, 5, VIII or IX dorsal and III anal spines, and dentition similar to *Acanthurus*. *Zebrasoma* would seem to be allied with *Acanthurus* in caudal armature and other characters, yet it has a reduced dorsal spine count like *Naso*.

Smith divides *Naso* as here defined into the five genera *Axinurus*, *Naso*, *Cyphomycter*, *Calli-*

canthus, and *Atulonotus*, the latter being erected for the species *Naso hexacanthus* (Bleeker) and *Naso vomer* (Klunzinger). He distinguishes *Atulonotus* from *Axinurus* by its possession of two instead of one plate on each side of the caudal peduncle, teeth with serrate edges; from *Callicanthus* by the presence of pointed teeth and from *Naso* and *Cyphomycter* by the lack of a conical frontal horn or swollen region at all stages. As previously discussed, the number of caudal plates and the presence or absence of a prominence on the forehead are not, in my opinion, characters of generic magnitude in the *Naso* group. Even dentition does not provide a consistent basis for separation. The teeth of *Naso unicornis*, although usually serrate, may be smooth, as indicated in Plate 3, Figure 1 of Aoyagi (1943). Therefore I leave *Naso* undivided and place *Atulonotus* in synonymy.

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NOTES

The Body Temperature of Wild *Rattus* spp. on the Island of Hawaii

During the course of a recent study concerning methods for the control of sylvatic plague in the Hawaiian Islands (Kartman and Lonergan, World Health Organ. Bul., in press), data were obtained on body temperatures of rats inhabiting Kaunamano Gulch in the Hamakua District of the Island of Hawaii. The rats concerned, *Rattus norvegicus*, *R. rattus* subspecies and *R. hawaiiensis*, were captured alive, subjected to ether anaesthesia (rarely to chloroform) and processed for certain physical data. Rectal temperatures were obtained with a mercury-filled glass thermometer after the animal had become quiescent. With few exceptions, temperature determinations were made at planes just below consciousness. This was fortunate since deeper planes of anaesthesia are thought to depress body temperature. Hypothermic effects in small animals are also known to be induced by certain microorganisms (Olitzki *et. al.*, 1942, Jour. Immunol. 45: 237–248). The rats reported on here were not affected by any known infection, but the presence of "inapparent" or asymptomatic plague cannot be excluded (Meyer *et al.*, 1943, Jour. Infect. Dis. 73: 144–157) even though it was not thought to have a high degree of probability.

Table 1 shows the body temperatures of these rats in relation to arbitrary weight classes. The data are based on the first capture of each animal. Although the mean body temperature of all individuals in each species was 37.6°C., animals in the lowest weight class (youngest) for each species had lower mean body temperatures. Although this may be due to the fact that younger animals have a more variable body temperature since they are in the process of acquiring homoeothermal ability it may have some relevance to current hypotheses concerning weight-temperature relations in mammals (Rodbard, 1950, Science 111: 465–466; 1953, Science 117: 256–257; Morrison and Ryser, 1952, Science 116: 231–232).

The overall mean body temperature of these wild rats closely approximates that recorded for the laboratory rat which is generally thought to be about 37.5°C. This correlation may be expected insofar as the commensal species are concerned, but it seems surprising in regard to the native *Rattus hawaiiensis*. Furthermore, the mean body temperature of *R. exulans* on the island of Guam was found to be about 35.9°C. (Baker, 1946, Ecol. Monog. 16: 393–408), and this species is closely related to the Hawaiian

TABLE 1

TEMPERATURE (C.) OF *Rattus* SPP. BY WEIGHT CLASSES

Rattus hawaiiensis			*Rattus rattus**		*Rattus norvegicus*	
Weight Class (Gm.)	Number examined	Mean	Weight Class (Gm.)	Number examined	Mean	Number examined	Mean
0–29	25	36.4	0–99	61	37.0	11	37.2
30–59	121	37.7	100–199	95	37.9	28	37.7
60–89	86	37.9	200–299	4	37.8	9	37.6
Total	232	37.6	Total	160	37.6	48	37.6

* *Rattus rattus rattus* and *R. r. alexandrinus*.

TABLE 2

TEMPERATURE (C.) OF *Rattus* SPP. BY SEX

	Rattus hawaiiensis		*Rattus rattus**		*Rattus norvegicus*	
	Number examined	Mean	Number examined	Mean	Number examined	Mean
Male	97	37.5	81	37.5	29	37.4
Female	135	37.7	79	37.6	19	37.9

* *Rattus rattus rattus* and *R. r. alexandrinus*

rat. On the other hand, a rat closely allied to the *R. rattus* group, *R. mindanensis*, also has been found to have a mean body temperature of 35.9°C. on Guam (Baker, 1946, *ibid.*). The reasons for these discrepancies are not known, but different environmental temperatures on Guam and Hawaii may be responsible in part.

It is of interest to note that the mean body temperature of both species of rats on Guam was 36.4°C. for females and 35.5°C. for males. No such wide differences were noted on Hawaii although the females tended to have slightly higher mean body temperatures than the males (Table 2).

Data from individual rats recaptured more than once indicated a marked variation in body temperature. Rectal temperatures in °C. of rats recaptured on the dates shown are given in the following examples:

Rattus hawaiiensis; Adult ♀; 7–1–52, 37.5°; 7–9, 37.8°; 8–14, 38.0°; 8–21, 38.1°; 10–15, 38.0°; 10–23, 37.0°. Adult ♂; 12–16–52, 37.8°; 1–13–53, 39.0°; 2–17, 38.8°; 2–18, 36.1°.

Rattus rattus; Adult ♂; 12–10–52, 37.8°; 12–11, 38.1°; 2–10–53, 38.2°; Juvenile ♀; 2–15–52, 39.0°; 2–18, 39.4°; 2–21, 37.8°; 3–4, 38.6°; 3–7, 37.2°; 3–19, 38.9°.

Rattus norvegicus; Adult ♂; 12–5–52, 36.8°; 12–16, 37.6°; 12–17, 37.6°; 12–18, 36.6°.

These data are not unexpected since studies on the laboratory rat have shown that the animal does not regulate its body temperature efficiently (Donaldson, 1924, Amer. Anat. Mem. [Wistar Inst.] No. 6 [2nd ed.]). The variable rectal temperature of small, warm blooded animals may suggest that the animal is in part poikilothermous. Nevertheless, this most probably is not a valid inference since these small animals show a profound physiological regulation but their adjustment to environmental changes is subject to varying degrees of thermal inertia (Herrington, 1940, Amer. Jour. Physiol. 129: 123–139). On the other hand, all warm-blooded species have a diurnal cycle and measurements at different periods in their cycle may affect the temperature. This may account in part for the variability in body temperatures observed here.

The writer acknowledges the suggestions of Dr. Simon Rodbard, Assistant Director, Department of Cardiovascular Research, Michael Reese Hospital, Chicago, who reviewed the manuscript.—*Leo Kartman, Communicable Disease Center, Public Health Service, U. S. Department Of Health, Education, and Welfare, San Francisco.*

News Note

The Geophysical Society of Hawaii, which is also the Mid-Pacific Region of the American Geophysical Union, will hold a Regional Meeting in Honolulu November 15 through 17, 1955. The meeting will be held in conjunction with a national meeting of the American Meteorological Society, and it is anticipated that a program based principally on various aspects of tropical meteorology, agricultural meteorology, meteorological forecasting, cloud physics, oceanography, hydrology, volcanology, and seismology will be established.

Persons interested in obtaining further information or in presenting papers at the meetings should get in touch with the secretary of the Geophysical Society of Hawaii, Larry Eber (Pineapple Research Institute, Honolulu, Hawaii), or the president, John F. Mink (P. O. Box 48, Honolulu, Hawaii).